ON-PUMP CORONARY ARTERY BYPASS GRAFT SURGERY VERSUS OFF-PUMP CORONARY ARTERY BYPASS SURGERY IN PATIENTS WITH LEFT VENTRICULAR DYSFUNCTION – A COMPARATIVE STUDY

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CERTIFICATE

This is to certify that the dissertation entitled **" ON-PUMP CORONARY ARTERY BYPASS GRAFT SURGERY VERSUS OFF-PUMP CORONARY ARTERY BYPASS SURGERY IN PATIENTS WITH LEFT VENTRICULAR DYSFUNCTION – A COMPARATIVE STUDY"** presented here is the original work done by Dr.U.Arun Kumar in the department of cardio thoracic surgery, Rajiv Gandhi Government General Hospital, Madras Medical College, Chennai 600 003, in partial fulfillment of the University rules and regulations for the award of M.Ch Cardio-thoracic degree under our guidance and supervision during the academic period from 2009 – 2012.

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DECLARATION

I solemnly declare that the dissertation entitled **"ON-PUMP CORONARY ARTERY BYPASS GRAFT SURGERY VERSUS OFF-PUMP CORONARY ARTERY BYPASS SURGERY IN PATIENTS WITH LEFT VENTRICULAR DYSFUNCTION – A COMPARATIVE STUDY ''** is the original work done by me at Rajiv Gandhi Government General Hospital, Madras Medical College, Chennai, during the M.Ch. course (2009 to 2012), under the guidance and supervision of Prof. S.Manoharan MS., M.Ch., Professor and H.O.D. Dept of Cardio-thoracic Surgery. The dissertation is submitted to THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY towards the partial fulfillment of requirement for the award of M.Ch IN CARDIO-THORACIC SURGERY.

Place : Chennai **Dr. U.ARUN KUMAR .**

Date :

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INTRODUCTION

Coronary artery disease is narrowing of the blood vessels that supply blood and oxygen to the heart. Coronary artery disease is the most common type of heart disease and leading cause of death worldwide. Each year, approximately 7.2 million people die from CAD.[1] Due to the increasing incidence across the world CAD has been described as an epidemic.[2] There has been a plateau phase in the western population, however the trend seems to be rising in the developing countries especially INDIA. [3] In INDIA there has been a steady increase in the patients with premature CAD, with aggressive disease which is very difficult for management. Premature CAD is defined as cardiac events occurring before the age of 55 years in men and 65 years in women.[4]

Etiology of CAD is multifactorial and needs identifying and correcting them. Some uncorrectable risk factors need to be taken into account while planning management. Hypertension, diabetes, obesity, tobacco and dyslipedemia have long been associated as risk factors for CAD. Lipoprotein-a, plasminogen activator inhibitor[5], insulin resist syndrome[6], hyper-homocysteinaemia, infection with Chlamydia pneumonia[7] have been implicated as risk factors for development of CAD among young patients in INDIA.

Management of CAD depends on the severity of the disease and the symptoms. Patients with significant coronary artery stenosis need some sort of intervention in the form of thrombolysis, percutaneous cardiac intervention or Coronary artery bypass grafting (CABG). Surgical management is by coronary artery bypass grafting which can be performed either On-pump (with the aid of heart-lung machine) or by Off-pump (with the use of stabilizers and without the use of heart-lung machine).

Treatment of patients with significant coronary artery stenosis is complicated when they present at a later stage with Left Ventricular Dysfunction. Myocardial revascularization in patients with Left Ventricular dysfunction prevents further myocardial damage, preserves the remaining myocardium and induces the recovery of systolic function of hypoperfused and hypocontractile LV myocardium segments. However post operative mortality rate in this group of patients is very high.[8] Since the advent of stabilizers, snares, shunts Off-Pump CABG has undergone dramatic improvement in techniques. It is considered a safe procedure in high risk patients[9] as it avoids the pump induced complications. OPCAB is feasible and applicable for patients with depressed left ventricular function.[10]

REVIEW OF LITRATURE

ANATOMY OF CORONARY ARTERIES

The Coronary arteries supply blood and oxygen to the myocardium. It comprises of two, the left and the right coronary arteries. The coronary arteries arise as the right and the left main coronary arteries which exit the ascending aorta through coronary ostia located in the upper third of the sinuses of Valsalva.

From the surgical point of view coronary arteries can be divided into four parts

- The Left main coronary artery
- The Left anterior descending coronary artery and its branches
- The Left circumflex coronary artery and its branches
- The Right coronary artery and its branches

The major coronary arteries form a circle and a loop about the heart[11,12]. The right coronary artery and the left circumflex arteries form the circle as they traverse the atrioventricular sulci. The loops between the ventricles are at right angles to the circle and are formed by the left anterior descending coronary artery and the posterior descending coronary artery as they encircle the septum.

Blood supply to the Left ventricle:

Posterior surface	-	Obtuse Marginal from the circle
Inferior surface	-	Right postero-lateral segment and PDA
Anterior surface	-	Diagonals and the loop
Ventricular septum	-	From the loop, LAD in front and PDA behind

Variability of the origin of the posterior descending artery is expressed by the term dominance. A left dominant circulation, which occurs in about 10% to 15% of hearts, is one in which the PDA is a branch, usually the last one of LCX artery. Right dominant circulation is one in which PDA arises from the terminal branch of RCA.

Left Main Coronary Artery

It extends from the coronary ostia in the left sinus of Valsalva to its bifurcation into the Left anterior descending artery and Left circumflex branches. It is usually 10 to 20 mm in length. Occasionally additional vessel originated from the left main artery and runs parallel to the left anterior descending artery (previously called Ramus Imtermedius) and is called first diagonal branch of the left anterior descending artery.

Left Anterior Descending Artery

It is a continuation of the left main artery, courses along the anterior interventricular sulcus. It supplies to the right ventricular free wall, the septum and the left ventricular free wall. One or more branches connect with the infundibular branches of right coronary artery and form an important route for collateral, the loop of Vieussens[13]. The septal arteries arise almost perpendicular which enables to identify left anterior descending branch in coronary angiogram.

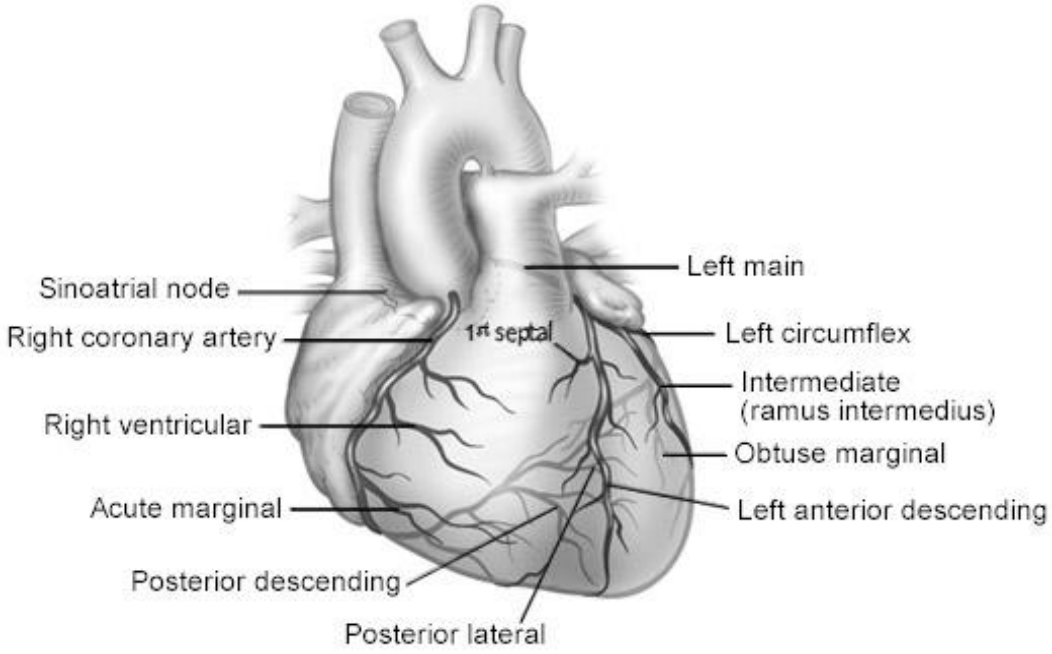
Left Circumflex Coronary Artery

It originates from the left main coronary artery at about right angles. A large branch the atrial circumflex artery arises from proximal part and courses around the left atrium near the atrioventricular groove. The ventricular branches of the

circumflex artery and the obtuse marginal arteries supply the obtuse margin of the heart.

Right Coronary Artery

It is a single large artery and courses down the right atrioventricular groove. It gives of branches that supply the right ventricular free wall from the atrioventricular sulcus in a looping fashion. The right coronary artery gives of the acute marginal branch and crosses the crux of the heart takes a characteristic deep U-turn giving off atrioventricular node artery. The right coronary artery terminates by dividing into right posterior descending coronary artery and right posterolateral segment artery. Variations in the right coronary artery are common and may have dual origin from right sinus of Valsalva in about 10% of hearts.



CORONARY ARTERIES

CORONARY ARTERY DISEASE

Coronary artery disease is the narrowing of the coronary arteries caused by thickening and loss of elasticity of their arterial walls that, when sufficiently severe, limits blood flow to the myocardium[14]. In the most severe form coronary artery disease completely occludes the coronary artery.

Coronary artery disease is the most common type of heart disease. Globally coronary artery disease is the leading cause of death and is predicted to remain so for the next 20years[15]. Historically coronary artery disease was diagnosed in autopsy specimens. The development of cine angiography by Sones and Shirey made possible the direct identification of stenotic and occlusive lesions in coronary arteries during life. This laid foundation to the development of coronary artery surgery.

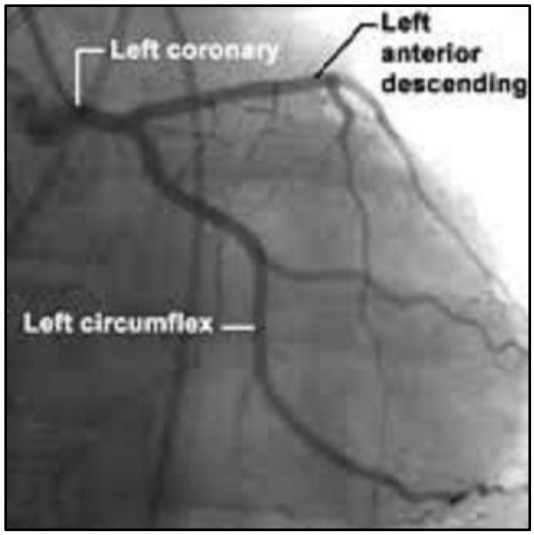
Atherosclerosis is the most common cause of stenotic coronary artery disease. There is focal intimal accumulation of lipid, blood and blood products, fibrous tissue and calcium. Fibro-lipoid plaques mature and become thick enough to cause luminal narrowing of the coronary arteries. This happens over a period of years, if there is no plaque rupture myocardium develops collateral blood supply to the affected area. Hemorrhage may occur suddenly within a plaque and may precipitate myocardial infarction or unstable angina. Platelet aggregation of the already affected vessels may precipitate a sudden cardiac event. Atherosclerotic coronary artery disease usually involves proximal portion of the large coronary arteries particularly at or beyond the sites of branching[16].

The clinical presentation of coronary artery disease is highly variable. It is usually suspected with the development of symptoms suggestive of angina pectoris or acute myocardial infarction. Chest discomfort with radiating pain to the neck and shoulder is the most common presentation, however patients may present with silent ischemia, known to occur in diabetics, atypical pain, and sometimes with features of congestive cardiac failure, cardiac arrhythmias, and sudden death. Myocardial ischemia and angina may occur with severe aortic valve disease, hypertrophic cardiomyopathy and idiopathic dilated cardiomyopathy.

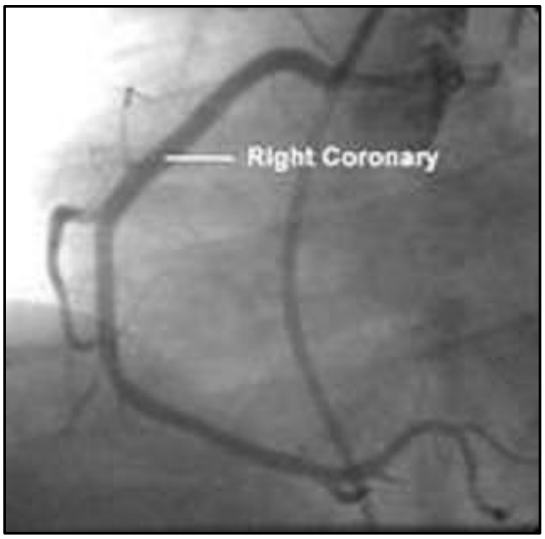
A complete history and clinical examination is conducted, and risk factors for development of cardiac disease are sought like family history of coronary artery disease, hypertension, diabetes, hypercholesterolemia and smoking. Patients with acute coronary syndrome are managed with urgent nasal oxygen, nitrates, aspirin, statin and blood pressure control, beta-blocker if not absolutely contraindicated. Electrocardiogram, Echocardiogram, chest X-ray, cardiac enzymes should be taken and immediate therapy instituted. Patients may require thrombolysis of angioplasty and some patients may require urgent surgical revascularization which needs to be carried out appropriately. The extent or distribution of anatomic coronary artery disease needs to be assessed and coronary angiography remains the gold standard for patients planned for surgical revascularization. Other investigations like dobutamine stress echocardiography, nuclear study for myocardial viability, three dimensional Echo are used as adjutants in planning treatment for the patients with significant coronary artery disease.

CORONARY ANGIOGRAPHY

Coronary angiography is considered the “gold standard” for evaluating and defying coronary artery disease. It is used to identify the exact location and severity of coronary artery disease.



LEFT CORONARY SYSTEM



RIGHT CORONARY SYSTEM

INDICATIONS FOR CORONARY ANGIOGRAPHY

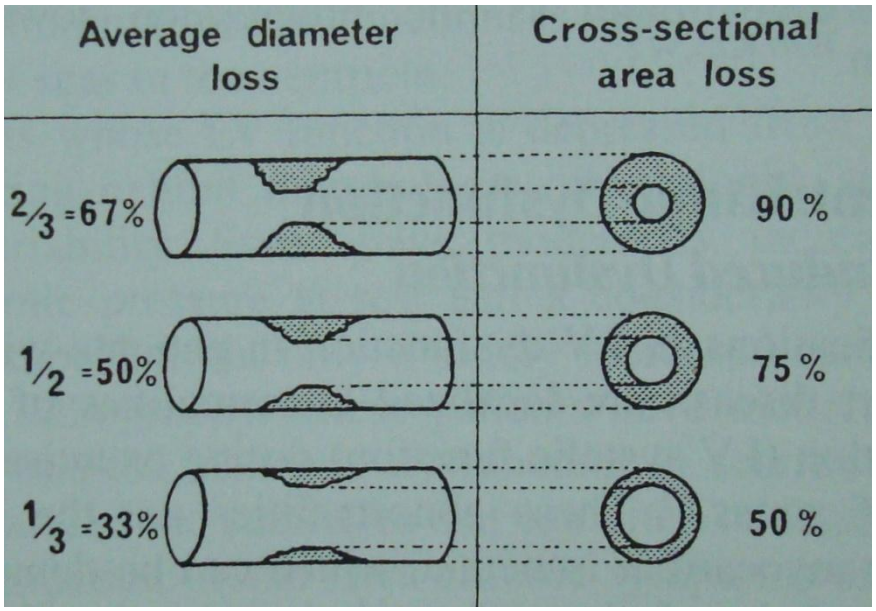
CLASS I : STEMI: acute, NSTEMI : <72hours

CLASS II : Disabling stable angina pectoris despite medical therapy or high risk criteria on Clinical assessment/non invasive testing or unexplained heart failure or survivors of cardiac arrest or severe ventricular arrhythmias or angina in conjunction with signs of heart failure or early recurrence of angina after coronary artery bypass or pre cardiac valve surgery.

CLASS IIa : Inconclusive or conflicting results after non invasive stress testing or unable to undergo non invasive testing or revascularization of performed procedures.

However, angiography currently remains an imperfect method as the severity of a visualized stenotic lesion may be underestimated and diameter of vessels distal to a stenosis is often underestimated.

A 75% cross sectional area loss (50%diameter) is considered an important but moderate stenosis and a 90% cross sectional area loss (67% diameter) is considered severe. The terms "coronary system" is to identify left anterior descending, left circumflex and right coronary arteries as these vessels (system) have several branches. Hence the term "system" is considered more accurate.



Diagrammatic representation of relationship between two methods of estimating severity of coronary artery stenosis[18]

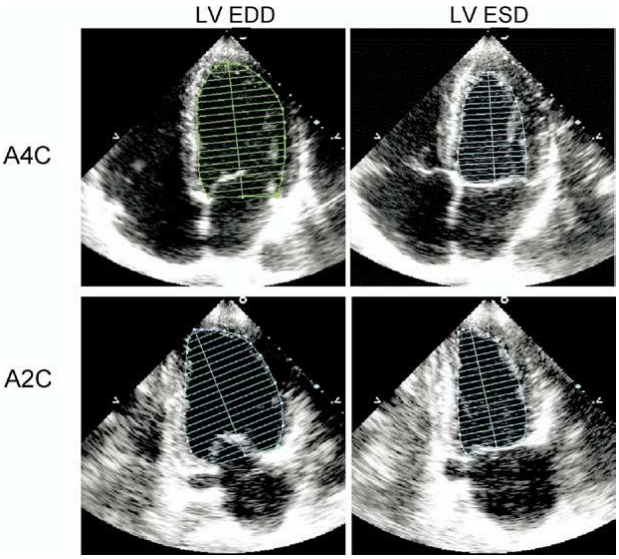
LEFT VENTRICULAR FUNCTION

Left ventricular function can be expressed as systolic function or diastolic function. Systolic function is determined by contractility of the ventricle and diastolic function is the compliance or extensibility of ventricle. The global left ventricular function is usually described by ventricular systolic function, most often ejection fraction. Ejection fraction the fraction of blood ejected during each systole. Ejection fraction is obtained by visual estimation from cineangiography or by quantitative angiography, by non invasive methods like radioisotope imaging and echocardiography.

$$E_f = \frac{SV}{EDV} = \frac{EDV - ESV}{EDV}$$

E_f – Ejection Fraction, SV- Stroke Volume, EDV- End Diastolic Volume, ESV – End Systolic Volume.

The normal range for Ejection fraction in 70kg healthy adult is 55 – 75%



CHAMBER VOLUMES BY ECHO

LEFT VENTRICULAR DYSFUNCTION

Localized abnormalities of regional wall motion during exercise may be the first indication of left ventricular dysfunction in patients with ischemic heart disease[19]. When myocardial ischemia becomes sufficiently extensive, global LV systolic function declines during exercise.

Reference limits and values of Left ventricular function

	Normal	**Mild dysfunction**	**Moderate dysfunction**	**Severe dysfunction**
Ejection fraction, %	≥ 55	45 - 54	35 – 44	< 35

Left ventricular dysfunction in patients at rest and under no stress has been considered the result of myocardial scar and less likely to benefit from coronary artery bypass grafting or percutaneous coronary intervention. However hibernating myocardium or stunned myocardium improves with myocardial revascularization and lead to improvement in left ventricular function.

CORONARY ARTERY BYPASS GRAFTING

No other operative procedure has prolonged more lives and provided more symptomatic relief in the history of medicine. Coronary artery bypass grafting is a surgical procedure to re route blood and oxygen around a blocked or compromised coronary artery. As a general rule vessels that are 1.5mm or larger with 50% to 70% or greater stenosis should be grafted.

INDICATIONS FOR CORONARY ARTERY BYPASS GRAFTING[20] :

Indications for CABG in Asymptomatic or Mild Angina

Class I evidence

- Significant left main coronary artery stenosis.
- Left main equivalent: significant (≥70%) stenosis of proximal LAD and proximal left circumflex artery.
- Three vessel disease. (Survival benefit is greater in patients with abnormal LV function; e.g., with an EF <0.50.)

Class IIa evidence

- Proximal LAD stenosis with 1- or 2-vessel disease.

Class IIb evidence

- One- or 2-vessel disease not involving the proximal LAD.

Indications for CABG in Stable Angina

Class I evidence

- Significant left main coronary artery stenosis.
- Left main equivalent: significant (≥70%) stenosis of proximal LAD and proximal left circumflex artery.
- Three vessel disease. (Survival benefit is greater when LVEF is <0.50.)
- Two-vessel disease with significant proximal LAD stenosis and either EF <0.50 or demonstrable ischemia on non-invasive testing.

- One- or 2-vessel coronary artery disease without significant proximal LAD stenosis, but with a large area of viable myocardium and high-risk criteria on non-invasive testing.
- Disabling angina despite maximal medical therapy, when surgery can be performed with acceptable risk. If angina is not typical, objective evidence of ischemia should be obtained.

Class IIa evidence

- Proximal LAD stenosis with 1-vessel disease.
- One- or 2-vessel coronary artery disease without significant proximal LAD stenosis, but with a moderate area of viable myocardium and demonstrable ischemia on noninvasive testing.

Class III evidence

- One- or 2-vessel disease not involving significant proximal LAD stenosis, in patients (1) who have mild symptoms that are unlikely due to myocardial ischemia or have not received an adequate trial of medical therapy and (A) have only a small area of viable myocardium or (B) have no demonstrable ischemia on noninvasive testing.

- Borderline coronary stenosis (50% to 60% diameter in locations other than the left main coronary artery) and no demonstrable ischemia on non-invasive testing.

- Insignificant (<50% diameter) coronary stenosis.

- Indications for CABG in Unstable Angina

Class I evidence

- Significant left main coronary artery stenosis.
- Left main equivalent: significant (≥70%) stenosis of proximal LAD and proximal left circumflex artery.
- Ongoing ischemia not responsive to maximal non surgical therapy.

Class IIa evidence

- Proximal LAD stenosis with 1- or 2-vessel disease.

Class IIb evidence

- One- or 2-vessel disease not involving the proximal LAD.

Indications for CABG in Poor LV Function

Class I evidence

- Significant left main coronary artery stenosis.
- Left main equivalent: significant (≥70%) stenosis of proximal LAD and proximal left circumflex artery.
- Proximal LAD stenosis with 2- or 3-vessel disease.

Class IIa evidence

- Poor LV function with significant viable, noncontracting, revascularizable myocardium without any of the aforementioned anatomic patterns.

Class III evidence

- Poor LV function without evidence of intermittent ischemia and without evidence of significant revascularizable, viable myocardium.

CONDUITS FOR CORONARY REVASCULARISATION

- Internal thoracic artery
- Great saphenous vein
- Radial artery
- Right gastro epiploic artery
- Inferior epigastric artery
- Splenic artery

INTERNAL THORACIC ARTERY GRAFT

Internal thoracic artery is the preferred conduit for coronary artery bypass and provides short term and long term benefit to all patient groups. Bilateral Internal thoracic arteries should be considered in young patients. The use of skeletonised internal thoracic artery does not affect long term survival but decreases sternal wound complications as it offers better sternal vascularity. 11 years patency of internal thoracic artery is about 88% and maybe improved with proper pharmacological management[21].Internal thoracic artery can potentially grow up to 1.4 times its original size to match the diameter of artery to which it is anastomosed[22]. Free internal thoracic artery grafts probably have patency rates comparable to those of pedicled internal thoracic artery grafts.

SAPHENOUS VEIN GRAFTS

Saphenous vein grafts are the most readily available Coronary artery bypass conduit. They provide immediate and reliable flow and time honored means of coronary revascularization during emergency. Saphenous veins used as free grafts develop diffuse intimal hyperplasia, which is considered a remodeling process. By 10 years, nearly all saphenous vein grafts show some sort of atherosclerotic changes. About 20% of vein grafts have proximal suture line stenosis within one year and 50% have some distal narrowing by one year.10 year patency is around 60% when grafted to other coronary vessels and is around 80% when left anterior descending artery is grafted[23].

RADIAL ARTERY

Radial artery is an alternative graft to saphenous vein which has patency that is better than vein grafts but not comparable with internal thoracic arteries. 5 year patency of radial artery is far superior to vein grafts. Radial artery should not be used to graft coronaries with less than 70% stenosis because of reduced patency[24].Radial artery immediately after harvesting is treated with blood and phenoxybenzamine flush and left for 5 to 30 minutes.96% to 98.3% graft patency has been demonstrated at the end of 5 years[25].

GASTROEPIPLOIC ARTERY GRAFT

Gastroepiploic artery graft is used when all other grafts have been exhausted and the patient is a deserving patient with significant stenosis. The 5 year and 10 year angiographic patency is reported as 84% and 63% respectively.

Other conduits like Splenic artery, arm veins and inferior epigastric artery have been used in patients when all other grafts have been used up, especially in redo coronary surgeries but their graft patency is much lower compared to the standard conduits. Patency rate over 2 years is around 50%.

TECHNIQUE OF CORONARY ARTERY BYPASS SURGERY

The prime objective of coronary artery bypass grafting is to obtain complete revascularisation by bypassing all severe stenosis. Coronary artery bypass grafting with use of total cardiopulmonary bypass through sternotomy remains the most widely used surgical technique. All other techniques compared with this, including Off-Pump coronary artery bypass grafting, coronary artery bypass grafting with smaller parasternal incisions or thoracotomy incisions.

ON-PUMP CORONARY ARTERY BYPASS SURGERY

Patient is prepared with upper limb arterial and venous access, general anesthesia, central venous access and placement of pulmonary artery catheter. Intravenous antibiotic is given one hour prior to skin incision. Nasogastric tube, Trans esophageal echo probe are placed if available. Baseline values of filling pressures, cardiac output, arterial blood gases, activated clotting time, hematocrit level and electrolytes are obtained.

Patient is painted with antiseptic solution and draped. Midline sternotomy is performed. Pericardium is opened and can be easy for access during emergency cannulation. Saphenous vein or radial artery is harvested at the same time. Pedicled internal thoracic artery is dissected by identifying the artery which can be facilitated by opening the pleura. Pedicle is scored about 0.5cm from the artery along its course

and dissection is started from 6th intercostals space heading proximally. All branches are doubly clipped and divided with diathermy. The first inter space artery which is a large branch is dissected and ligated as it may lead to internal thoracic artery steal. Once internal thoracic artery is dissected, the distal end is divided after systemic heparinisation and bull dog is placed to control bleeding. It is placed with papavarine soaked gauze to avoid spasm. Skeletonised internal thoracic artery does not affect long term survival[26].

Cardiopulmonary bypass is initiated with ascending aortic and Right atrial cannulation and the core temperature is cooled to mild hypothermia. The coronary arteries that need to be grafted are marked prior as it may be difficult after cardioplegia is administered. Root cardioplegia cannula is placed and can be used for venting and deairing as required. Antegrade cold cardioplegia is adequate for most of the cases and in cases where stenosis is significant and large myocardium may be compromised, retrograde cardioplegia cannula is placed and cardioplegia delivered in addition to ante grade cardioplegia.

Ante-grade cold cardioplegia is given and heart arrested in diastolic. As a general measure, the first performed graft is usually that of the inferior circulation, followed by the lateral wall, the diagonal system and the left anterior descending artery. The most proximal disease free portion of the coronary artery to be grafted, immediately after the most distal disease involvement is selected for anastomosis. Epicardium is incised with size 15 blade, and the blade's pointed tip is used in oblique fashion to enter the artery and care is taken not to injure the posterior wall. The incision is enlarged with a Pott's scissors to 4 to 6mm for end to side anastomosis. The distal ends of the conduit are incised longitudinally for 20% larger than the coronary arteriotomy. Bites using 8-0 prolene for internal thoracic artery graft and 7-0

prolene for vein grafts are taken in such way as to create a “cobra head” appearance. It is strongly advocated that native flow of the coronary artery vessels are not impeded as this may lead to disastrous consequences once the graft flow is occluded or thrombosed.

Branch artery from the same systems which are in alignment and need to be grafted, can be grafted by sequential technique where a ‘Y’ graft is performed with single graft from aorta supplying two adjacent branches. Transverse sequential side to side anastomosis is contraindicated with arterial grafts[27].

Coronary endarterectomy is performed is performed in selected cases where severe diffuse disease is present and no anastomotic site is present for adequate grafting that supplies ischemic or viable myocardium.

Once the distal anastomosis is performed, bull dog clamp placed over the internal thoracic artery is removed and core rewarmed. Aortic cross clamp is released and partial aortic clamp is placed. Aortic punch is used and adequate size aortic tissue is removed with a 4mm or 4.5mm aortic punch. Proximal anastomosis is performed using 6-0 prolene. Vein graft is spatulated 20% larger than the aortic punch to create “cobra head” appearance.

Graft patency can be assessed with hybrid theatre, on table coronary angiogram, or probing distal and conduit vessels prior to tying down sutures, transit time flow can be measured[28], high frequency epicardial echocardiography and power Doppler imaging. Indocyanin green intraoperative fluorescent cardiac imaging may be performed safely[29].

After the graft patency is confirmed, partial clamp is released and patient is weaned of cardiopulmonary bypass. Protamine is given to neutralise the systemic heparinisation and haemostasis secured. The grafts are fixed in position to avoid torsion and kinking of the grafts. Sternum is closed in layers with pleural or pericardial /mediastinal drains.

OFF-PUMP CORONARY ARTERY BYPASS SURGERY

With the development of better stabilizers, Off-Pump bypass can be performed in patients with three system disease and with left main coronary artery disease[30].Close communication between the anesthetist and surgeon is a must while performing Off-Pump revascularisation.

Patient is anesthetized using the same precautions as in On-Pump bypass surgery. Median sternotomy is done. Internal thoracic artery, saphenous vein is harvested and heparin administered. Target vessel to be grafted is identified. Hypothermia is avoided. Left ventricular surface can be exposed with heavy suture opposite to oblique sinus and traction over the suture to the left of the heart.

Generic stabilizing devices are used with controlled suction over epicardium. Octopus stabilizer can be used with minimal or no damage to the epicardium with adequate stabilization of the ventricular wall. Starfish another generic device can be used with suction to the apex, which is used for grafting the obtuse marginal branches and for posterior descending artery. The combination of octopus and starfish stabilizers enables safe anastomosis to be performed with little effect on hemodynamics.

Epicardium is teased and arteriotomy is performed. After adequate arteriotomy is performed, an intra coronary shunt of adequate size is placed in position to facilitate distal flow while performing the anastomosis. Before tying down the sutures intracoronary shunt is removed and sutures tied. Bleeding from arteriotomy site can be controlled by encircling stitch which is placed proximal and distal to the anastomotic site.

The use of aortic cross clamp/ aortic cannulation is thought to be a source of emboli shower in diseased aorta[31] and this can be avoided with "no touch technique". Here the aorta is not handled and arterial anastomosis is done with complete arterial revascularisation is done with bilateral internal thoracic artery in "Y" fashion, right internal thoracic artery used as a free graft. The grafts are fixed using sutures to avoid torsion. Hemostasis is checked and the sternum is closed in layers with drains.

POST OPERATIVE MANAGEMENT

Patient's hemodynamic status is monitored in the immediate post operative period with continuous monitoring. Patients may require inotropic support with Dopamine or Epinephrine. Tablet aspirin 325mg may be given 1 hour post operatively and is continued for at least 1 year. Post operative beta blockers are continued on first post operative day at half the dosage to avoid new onset atrial fibrillations and to avoid arrhythmias. Post operative electrocardiogram, echocardiogram and chest X-ray are obtained. Patients with left ventricular dysfunction and normal renal function are started on Ramipril[32].Patients are started on statins prior to discharge ,as it reduces the rate of sudden death and other un toward cardiac events.

In the event of unsuccessful weaning off of patients from cardio pulmonary bypass, in spite of inotropic supports, Intra aortic balloon counter pulsation may be required. Intra aortic balloon pump is inserted through femoral artery and the balloon is placed just distal to left subclavian artery and diastolic pressure augmentations along with afterload reductions and decreasing myocardial oxygen demand. In case of elevated pulmonary wedge pressure and low cardiac index and low blood pressure, left ventricular failure is suspected and left ventricular assist device is warranted.

POST OPERATIVE MORBIDITY

The common complications encountered in patients undergoing coronary artery bypass graft surgery are post operative bleeding, low cardiac output syndrome, renal dysfunction, neurologic events, new onset arrhythmias and deep sterna wound infections.

POST OPERATIVE BLEEDING

Meticulous surgical technique and hemostasis is a must in every coronary artery bypass surgery and so it need not be emphasized. The pre disposing factors for post operative transfusions include female gender, low pre operative hematocrit, long pump time, recent thrombolytic therapy and age. Re-exploration for post operative bleeding is indicated if bleeding exceeds 400ml in an hour or 300ml for 2 hours or 200ml for more than 4 hours or if pericardial tamponade is suspected. The most untoward consequence of homologous blood transfusion is immunosuppression and is associated with increase in wound infections and remote infections.

NEUROLOGICAL COMPLICATIONS

Neurological abnormalities are divided into

- Type I deficit : Major focal neurologic deficit
- Type II deficit: Global deterioration of intellectual function or memory[33].

In a study involving large series of coronary bypass surgery patients, incidence of type I deficit was 3.1% and that of type II deficit was 3.0%[31].Atherosclerosis predisposed to type I deficit but was not a predictor for type II deficit. Type II deficit was related to alcoholism, atrial fibrillation, hypertension and diabetes.

Taggart and co workers noted that similar patterns of early decline and recovery of cognitive function at 3 months in patients undergoing coronary artery bypass with and without cardiopulmonary bypass suggest that cardiopulmonary bypass is not the major cause of post operative cognitive impairment[34]. Ascione also showed no significant difference between the On-Pump and Off-Pump patients, in incidence of type I deficit[35].

RENAL DYSFUNCTION

Post operative serum creatinine levels of 177µmol/L or pre operative to post operative increase of at least 62 µmol/L is identified as renal dysfunction[36].The risk factors for development of renal dysfunction include age>70 years, congestive heart failure, diabetes mellitus, pre operative serum creatinine 124 to 177 µmol/L, re do coronary artery surgery and cardio pulmonary bypass >3 hours. The Off-Pump coronary artery bypass surgery may be associated with lower incidence of renal dysfunction[37].The overall risk for development of post operative renal dysfunction was 7.7% and 1.4% requiring dialysis.

ARRHYTHMIAS

20% to 40% of patients undergoing coronary artery bypass surgery develop onset atrial fibrillation in the second post operative day[38]. Cases include pericardial inflammation, excessive catecholamine production, post operative autonomic imbalance and neuro-humoral imbalance. Predictors of development of atrial fibrillation include advanced age, prolonged cross clamp time, chronic obstructive pulmonary disease and withdrawal of beta blockers. Patients with persistent atrial fibrillation should be anticoagulated. Prophylactic use of sotalol, amiodarone, resumption of beta blockers with magnesium supplementations has been effective.

Exercise induced ventricular tachycardia or ventricular fibrillation causes poor prognosis in patients with coronary artery disease. Complete revascularisation of stenosed vessels generally does not decrease the frequency or severity of exercise induced or resting ventricular arrhythmias[39].A study of 900 patients with depressed LV function(EF <36%) and abnormalities of resting signal –averaged electrocardiograms suggested increased risk for post operative ventricular fibrillations[40]. Patient's survival in whom, cardioverter-defibrillator was implanted was not improved.

DEEP STERNAL WOUND INFECTION

Mediastinitis and deep sterna wound infection occur in 0.7% to 2.4% of patients after coronary artery bypass surgery and carries a mortality of nearly 15%[41]. Risk factors include obesity, use of bilateral internal thoracic artery in diabetics, obese, male gender and advanced age. Complications can be prevented by clipping chest hair, rather than shaving pre operatively, intravenous antibiotic prophylaxis,

keeping operative time to a minimum, avoiding excessive electrocautery, aseptic precautions, favoring use of skeletonised internal thoracic artery. Deep sternal wound infection is treated aggressively with surgical debridement and vascularised muscle flap cover[42].

MYOCARDIAL INFARCTION

Development of new Q waves in the electrocardiogram post coronary artery bypass surgery is universally indicative of peri-operative myocardial infarction. Underlying causes relate either to incomplete or unsuccessful revascularisation or inadequate myocardial protection. Prevalence of myocardial infarction is highly variable and is approximately 2.5% to 5%[43]. Survival following post operative myocardial infarction is adversely affected and freedom from subsequent myocardial infections also declines[44].

LEFT VENTRICULAR FUNCTION

The greatest survival benefit after coronary artery bypass surgery is in patients with three vessel disease or left main coronary artery disease and depressed left ventricular function. The left ventricular function indices rise 5% to 12% post coronary artery bypass surgery in patients with pre operative left ventricular dysfunction, as a result of improvement in the function of stunned or hibernating myocardium45.Resting perfusion defects are improved in at least 65% of patients after coronary artery bypass surgery. Improvement in segmental wall motion has been observed even in areas of scarring by 12 months and as early as 3 months. When segmental wall contraction does not occur after coronary bypass surgery, incomplete

revascularisation is the cause in some patients[46]. When pre operative Left ventricular dysfunction is severe however, the scarring is extensive and improvement is limited.

Several studies confirm that pre operatively depressed resting global left ventricular systolic function, estimated by ejection fraction is less depressed as early as 2 weeks after coronary artery bypass surgery[47]. Coronary angiography showed that three of four patients with persistence of an abnormal response to exercise had incomplete revascularisation. Five years or more improvement of left ventricular function was seen in some patients, while some deteriorated. The depression in Left ventricular function post revascularisation was attributed to low graft patency. Left ventricular diastolic function, more specifically left ventricular "relaxation" is also improved by successful coronary revascularisation and improvement may be immediate[48].

EXERCISE TOLERANCE

The decreased ejection fraction with exercise that is characteristic of ischemic heart disease is absent 2 weeks after coronary artery bypass surgery in most patients[49].This favourable result is brought only by coronary artery bypass surgery and does not result from collateral circulation alone, even when extensive.

MORTALITY

The overall mortality of coronary artery bypass surgery (deaths occurring in hospital and 30 days out of hospital after procedure) is 3%. Risk of peri operative mortality is increased advanced age, female sex, diabetes mellitus, poor left ventricular function, high creatinine levels, peripheral vascular disease, pulmonary disease, left main coronary artery disease and increasing extent of coronary artery

disease. Emergent coronary artery bypass surgery for hemodynamic instability has mortality of nearly 30%. Kirklin reported that survival after coronary artery bypass surgery was 92% at 5 years and 81% at 10 years. Single internal thoracic artery was a predictor of mortality, late myocardial infarction or late re operation when compared with bilateral internal thoracic artery grafting[50].

SYSTEMIC CONSEQUENCES OF CARDIOPULMONARY BYPASS

Complexity of cardiopulmonary bypass is that blood does not naturally 1) circulate through non endothelial lined channels 2) Contain gaseous and particulate emboli 3) experience non physiologic shear stresses. Also, body is unaccustomed to non pulsatile aortic pressure.

During cardiopulmonary bypass, a number of physiologic variables are under direct external control, in contrast to the situation in intact humans. These include total systemic blood flow, input pressure waveform, systemic venous pressure, pulmonary venous pressure, hematocrit and chemical composition of initial perfusate, arterial oxygen, carbon dioxide, nitrogen levels and temperature of the perfusate and patient. Other variables in part controlled by cardiopulmonary bypass include systemic vascular resistance, total body oxygen consumption, mixed venous oxygen levels , lactic academia and pH.

Largely uncontrolled variables include to a greater or lesser degree , all components of the process of inflammation, incited in large part by the organism recognizing foreign surfaces across which blood passes as ‘non self’.

Unfavorable aspects of use of cardiopulmonary bypass includes 1)Diffuse bleeding 2)Whole body edema especially in small patients 3)Severe and truly malignant hyperthermia 4)Pulmonary dysfunction 5)Cardiac depression and decreased performance 6)Renal dysfunction 7)Neurologic disturbances.

AIM OF THE STUDY

1. To study the epidemiology of coronary artery disease with left ventricular dysfunction in the local population.
2. To compare the outcome in the On-pump versus Off-pump bypass surgeries in patients with left ventricular dysfunction.
3. To analyze the various complications of coronary artery bypass surgery.
4. To analyze and compare the advantages and disadvantages of On-pump versus Off-pump bypass surgeries in patients with left ventricular dysfunction.
5. To analyze the left ventricular ejection fraction improvement in patients with left ventricular dysfunction, following coronary artery bypass surgery.

MATERIALS ANF METHODS

This study is a non randomized observational study based on coronary artery disease in patients with left ventricular dysfunction admitted in the Department of Cardiothoracic Surgery, Rajiv Gandhi Government General Hospital, Chennai between January 2010 and January 2012.

Patients with coronary artery disease with left ventricular dysfunction (ejection fraction less than 55%) awaiting coronary artery bypass surgery were taken up for the study. Patients were categorized into On-pump group and Off-pump group. Categorization into groups was done by the operating surgeon by prior review of the coronary angiogram, clinical examination and echo report. Patients were explained, about the proposed surgery, line of management and the study conducted in detail and consent was obtained. The need for post operative follow up and the life style modification and need for adherence to medication was explained in detail.

Of all 81 patients who underwent surgical treatment during January 2010 and January 2012, 42 patients were categorized under On-pump group and operated upon using Cardiopulmonary bypass for coronary artery bypass surgery and 39 patients were categorized under Off-pump group and operated upon using Off-pump coronary artery bypass surgical technique.

Patients having normal or above normal left ventricular ejection fraction were excluded from the study. Patients who were operated on emergency basis, patients who had previous cardiac surgery and patients with associated ischemic valvular regurgitation, ventricular septal rupture, left ventricular aneurysm were excluded from the study. Triple, double, single vessel diseases were included in the study.

The first decision whether to perform On-pump or Off-pump surgery was decided by the operating surgeon after inspecting the vessels, the technical feasibility of the procedure and the hemodynamics of the patient. No reduction in the number of grafts for the sake of performing Off-pump bypass surgery was accepted. Even if one of the planned vessels was difficult to be grafted Off-pump, the surgery was converted to On-pump and revascularisation completed. The major reason for opting for On-pump surgery was difficult exposure of lateral vessels, diffuse disease, and unstable hemodynamics. 42 patients were operated On-pump and 39 patients were operated Off-pump. Of the 39 patients who were operated Off-pump two patients were converted to On-pump and were included in the On-pump category.

Aspirin was stopped three days prior to surgery and, clopidogrel 5-7 days prior to surgery. Patient was continued on Beta blockers till the day of surgery. Aspirin was restarted 6 hours post surgery. All the patients were operated under general anaesthesia.

All procedures were performed through midline sternotomy incision. Conduits used were left internal thoracic artery, saphenous vein grafts. In the On-Pump group, patient's aorta and right atrium was cannulated, cardiopulmonary bypass conducted with mild hypothermia using roller pump, non pulsatile flow at 2.4L/min/m^2 and mean arterial pressure maintained above 60mm Hg. Cold blood cardioplegia was given to arrest the heart. In Off-Pump coronary artery bypass surgery stabilization of heart for performing distal anastomosis was done with Octopus generic stabilizer or star-fish apex stabilizer.

Internal thoracic artery anastomosis was done using 8-0 prolene and venous grafts were anastomosed using 7-0 prolene. Proximal aorto-saphenous vein graft was

performed using 6-0 prolene. Proximal grafts were done using a side biting partial clamp on aorta.

Post operatively patient was carefully monitored in the intensive care unit and all parameters corrected as necessary. Patients were followed up for development of complications and progress of the patient.

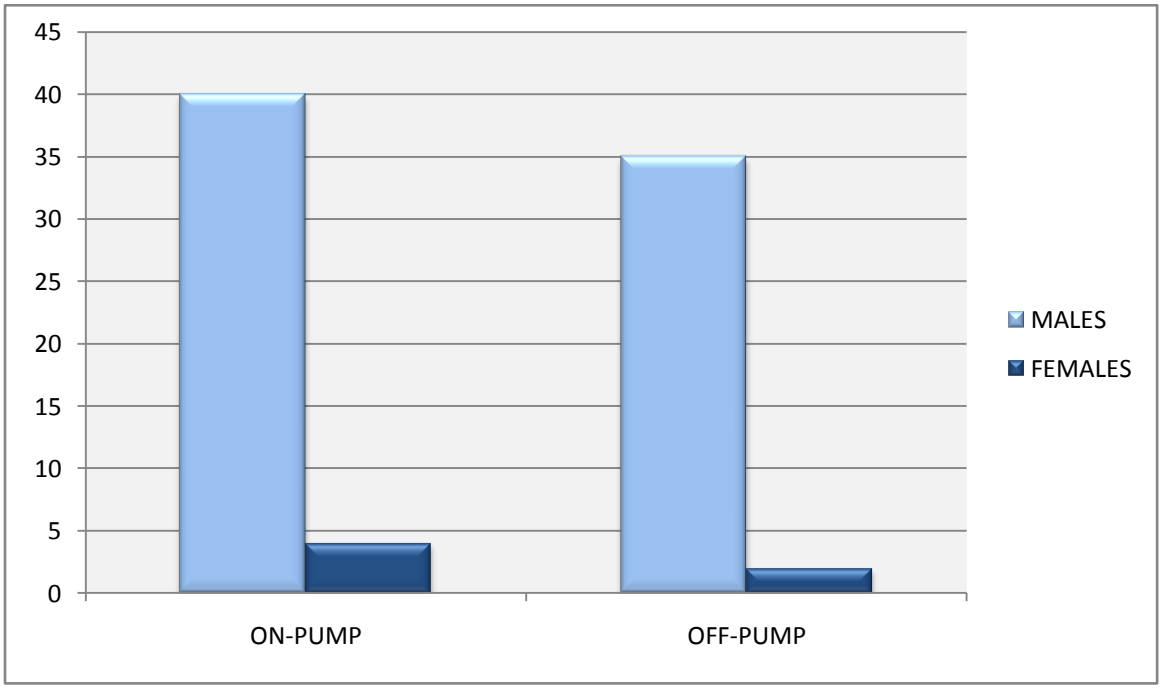
Statistical analysis was done by collecting pre operative, operative data, post operative data and expressed as percentage, mean and standard deviation wherever applicable.

OBSERVATIONS

SEX DISTRIBUTION

	ON-PUMP	OFF-PUMP	Converted
MALES	38	35	2
FEMALES	4	2	0
TOTAL	44	37	2

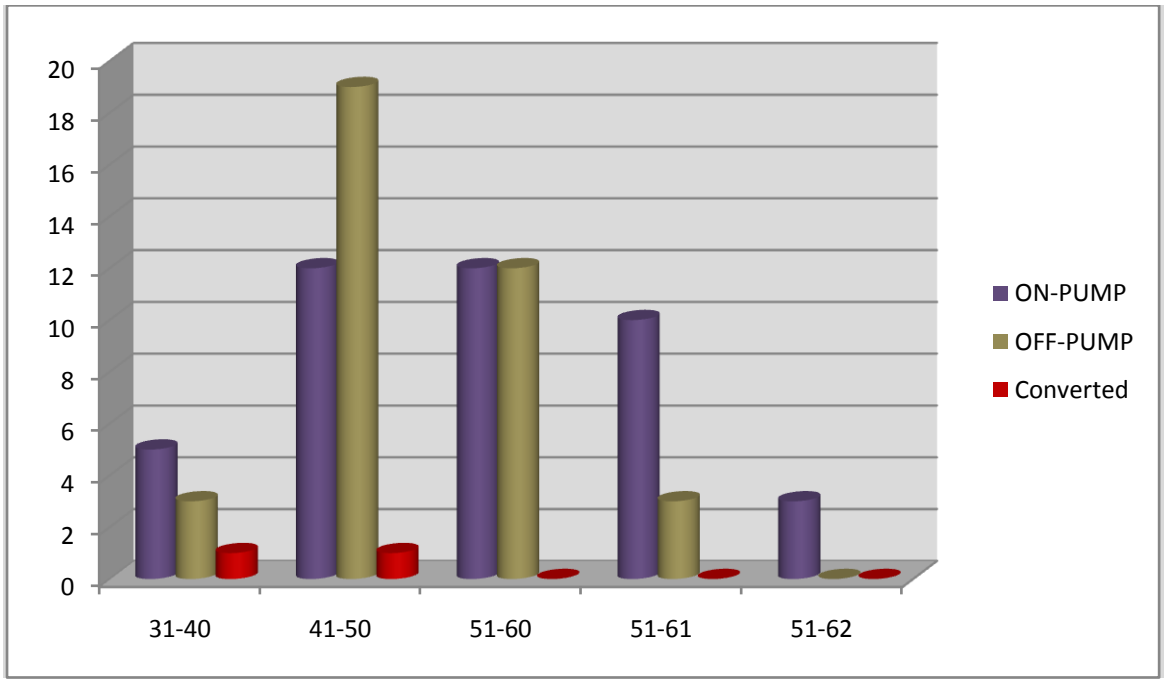
	ON-PUMP	OFF-PUMP
MALES	90.9%	94.5%
FEMALES	9.1%	5.4%



Of the 44, ON-Pump patients, 38 were males, 4 were female patients. In the OFF-Pump group 35 were male patients and 2 were female patients. Two patients in the OFF-Pump group were converted to ON-Pump group and the total number of male patients in ON-Pump group was 40, females 4. On calculating the percentage of patients, 90.9% on the ON-Pump group were males, and 94.5% on the OFF-Pump group were males, females were 9.1% and 5.4% respectively.

AGE DISTRIBUTION

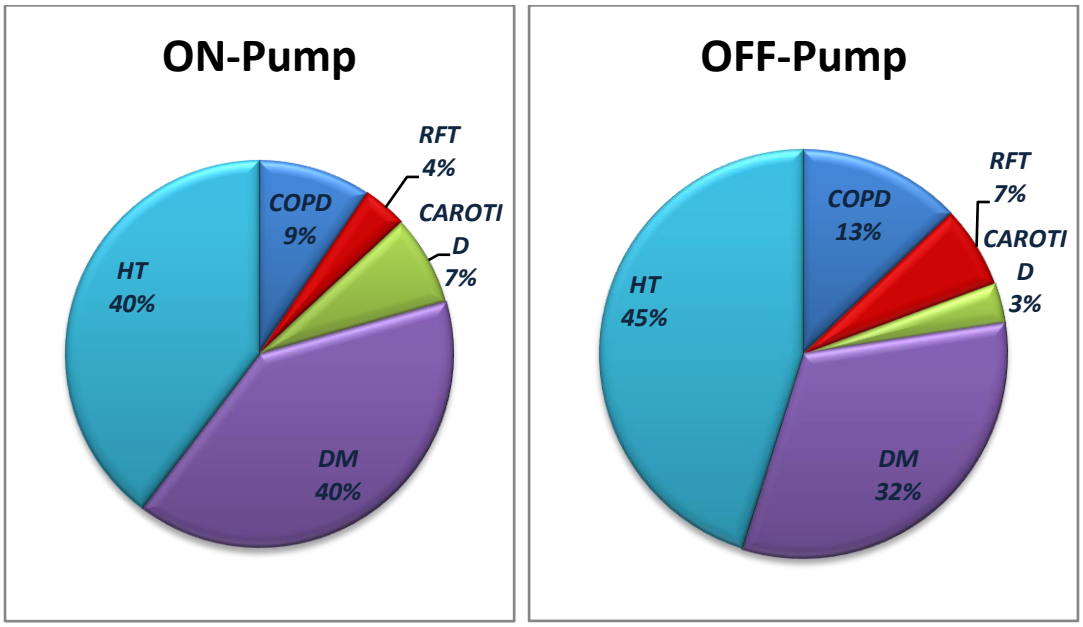
	31-40	41-50	51-60	61-70	71-80
ON-PUMP	5	12	12	10	3
OFF-PUMP	3	19	12	3	0
CONVERTED	1	1			



The majority of the patients belonged to the 41-60 years age group. The mean age in the On-Pump group of patients was 53.4 years and in the OFF-Pump group was 49.9 years. The percentage of patients in the age group 41-60 years was 54.54% in the ON-Pump group and 83.7% in the OFF-Pump group. Two patients were converted to the ON-Pump group and 1was from 31-40 years age group and the other from 41-50 years age group.

CO-MORBID FACTORS

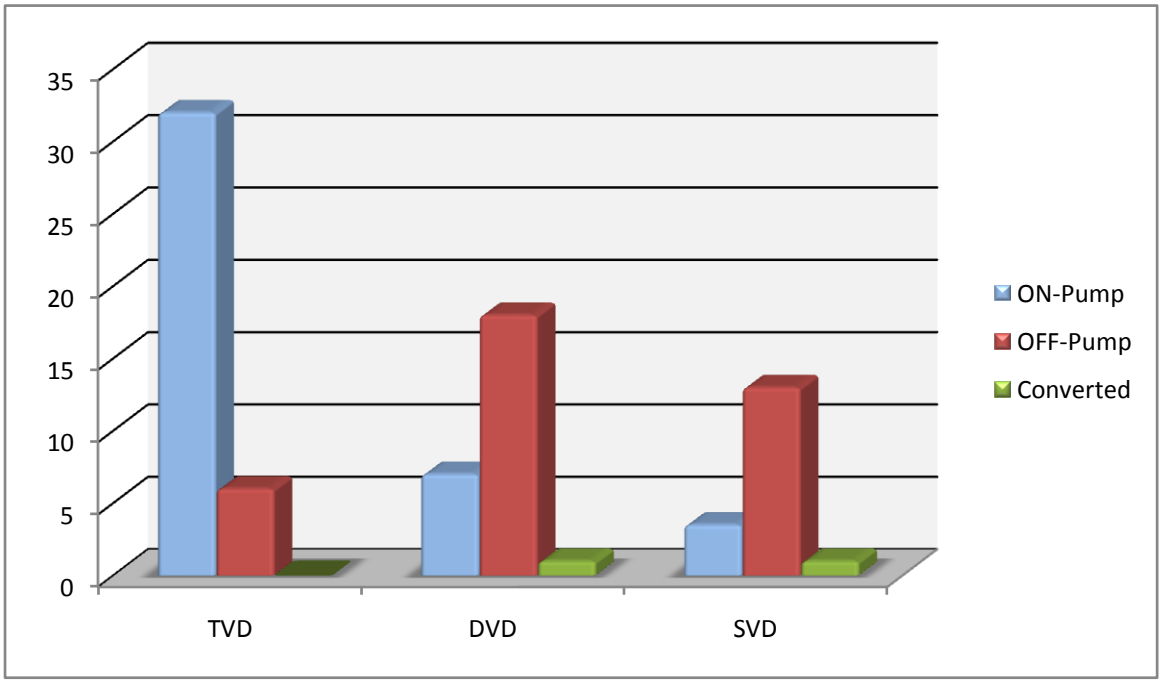
	COPD	↑RFT	DM	CAROTID DISEASE	HT
ON-Pump	5	2	19	4	21
OFF-Pump	4	2	10	1	14
Converted			2		



Diabetes and Hypertension was found to be the most common co-morbidity encountered. 19 patients had diabetes and formed 40% in the ON-Pump group, 10 patients had diabetes in the OFF-Pump group forming 32%. Hypertension was found in 21 patients in the ON-Pump group and 14 patients in the OFF-Pump group which was 40% and 45% respectively. 38.2% of the study patients had Diabetes and 43.2% of the study patients had Hypertension.

CORONARY SYSTEM AFFECTED

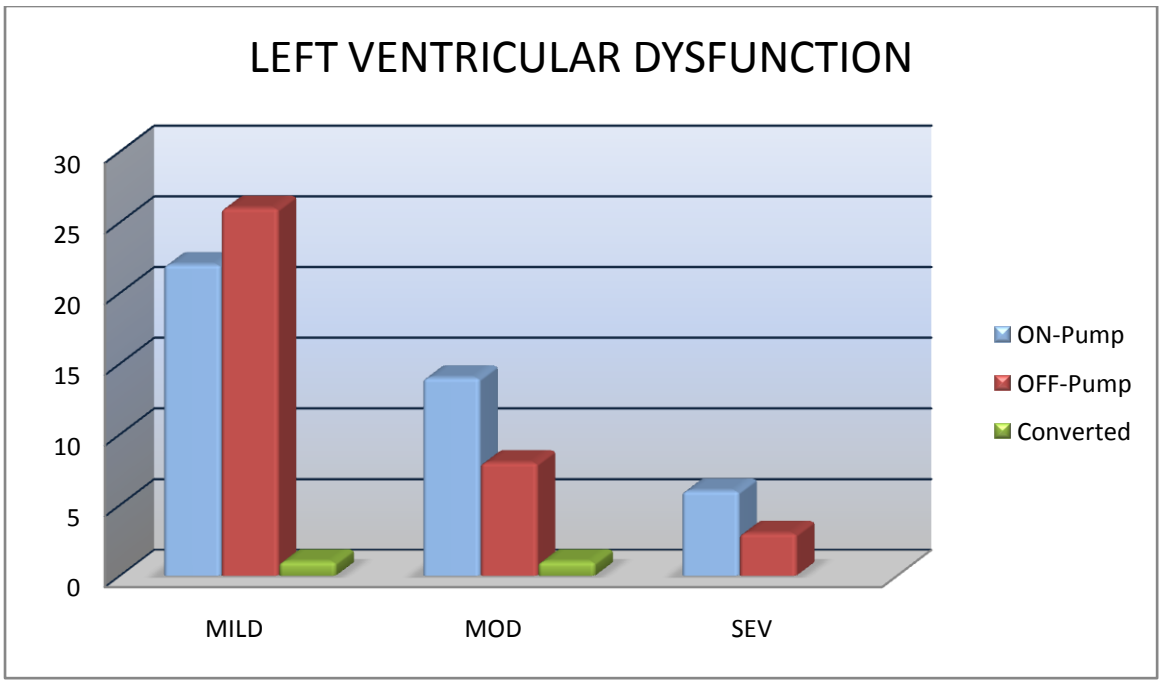
	TVD	DVD	SVD
ON-Pump	32	7	3
OFF-Pump	6	18	13
Converted		1	1



Of the 81 patients in the study, 46.9% had triple vessel disease, 32% had double vessel disease and 20% had single vessel disease. Of the 38 triple vessel disease patients 84.2% had ON-Pump surgery and 15.7% had OFF-Pump surgery. 30.7% of double vessel disease was operated ON-Pump including 1 case which was converted and 69.23% OFF-Pump. Among patients with single vessel disease 23.5% were operated ON-Pump including 1 patient who was converted and 76.4% were operated OFF-Pump.

LEFT VENTRICULAR FUNCTION

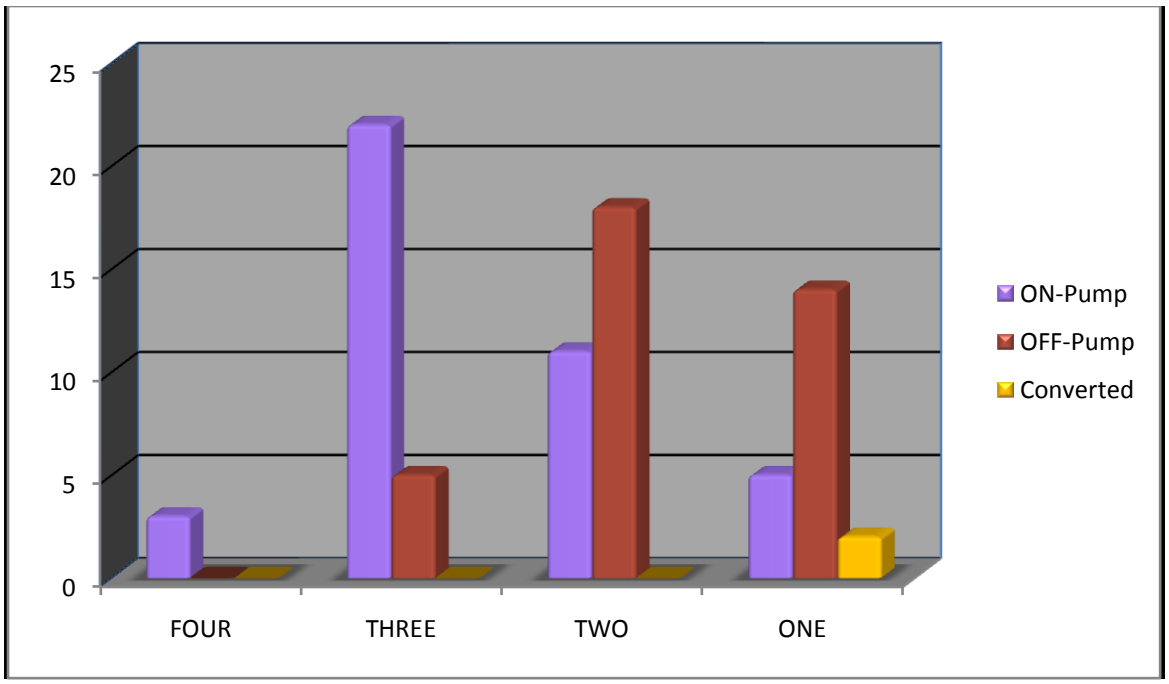
	MILD	MODERATE	SEVERE
ON-Pump	22	14	6
OFF-Pump	26	8	3
Converted	1	1	



In the present study major strength of patients belonged to the mild category. 49 patients belonged to the mild category and 46% of them were operated in the ON-Pump group including one patient who was converted, remaining 53% of patients were operated in the OFF-Pump group. 15 patients in the ON-Pump group had moderate left ventricular dysfunction including one patient who was converted and 6 patients had severe dysfunction. 8 patients in the OFF-Pump group had moderate left ventricular dysfunction and 3 had severe dysfunction.

NUMBER OF GRAFTS

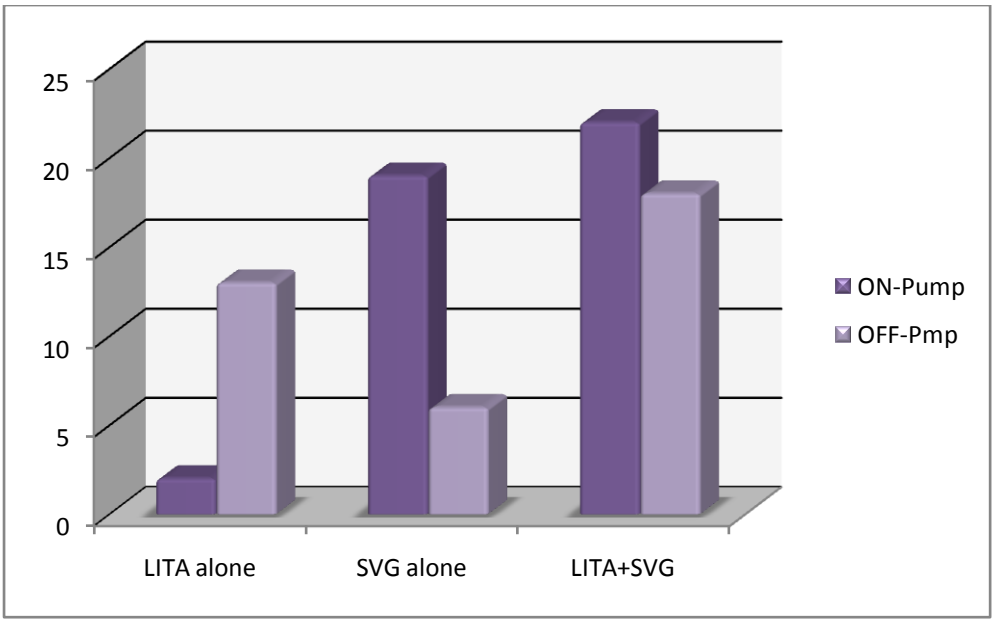
	FOUR	THREE	TWO	ONE
ON-Pump	3	22	11	5
OFF-Pump	-	5	18	14
Converted	-	-	-	2



Among the patients who were operated in ON-Pump group, 6,9% had 4 grafts, 53.6%had two grafts, 26.8% had two grafts, 12% had single graft. In the OFF-Pump group 13.5% had 3 grafts, 48.6% had two grafts and 37.8% had single graft

TYPE OF GRAFT

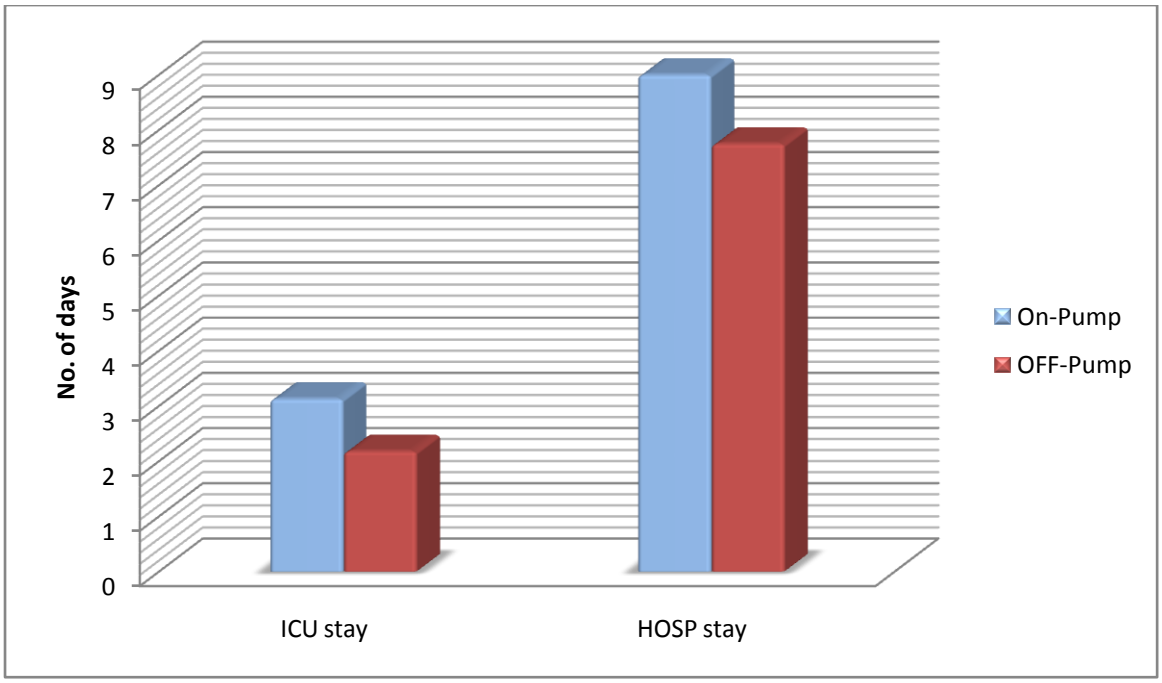
	LITA alone	SVG alone	LITA+SVG
ON-Pump	2	20	22
OFF-Pump	13	6	18



Left internal thoracic artery and the saphenous vein grafts were used as conduits. Majority of the cases were performed with the combined use of internal thoracic artery and the saphenous graft. 22 patients were revascularized with LITA and SVG conduits in the ON-Pump group and 18 patients in the OFF-Pump group. SVG alone was used in 20 patients in ON-Pump group and 6 patients in off pump group. Of the 37 patients, 13 patients were revascularized with LIMA alone in the OFF-Pump group and 2 patients were revascularized with LIMA alone in the ON-Pump group which was 35.1% and 4.5% respectively.

DURATION OF CARE

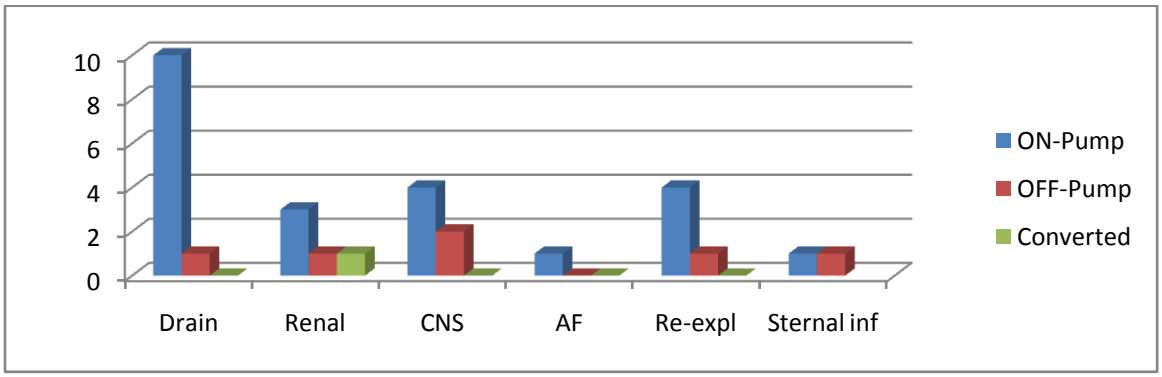
	VENTILATION	ICU STAY	HOSPITAL STAY
ON-Pump	14.3±8 hrs	3.13 days	9±2.1 days
OFF-Pump	8.9±4 hrs	2.18 days	7.75±2 days



Duration of Post operative care, the duration of ventilation was 14hrs±8 hrs in the ON-Pump group and 8.9±4 hrs in the OFF-Pump group. The duration of mean intensive care was 3.13 days in the ON-Pump group and 2.18 days in the OFF-Pump group. The average number of days in the hospital in the ON-Pump group was 9±2 days and in the OFF-Pump group it was 7±2 days.

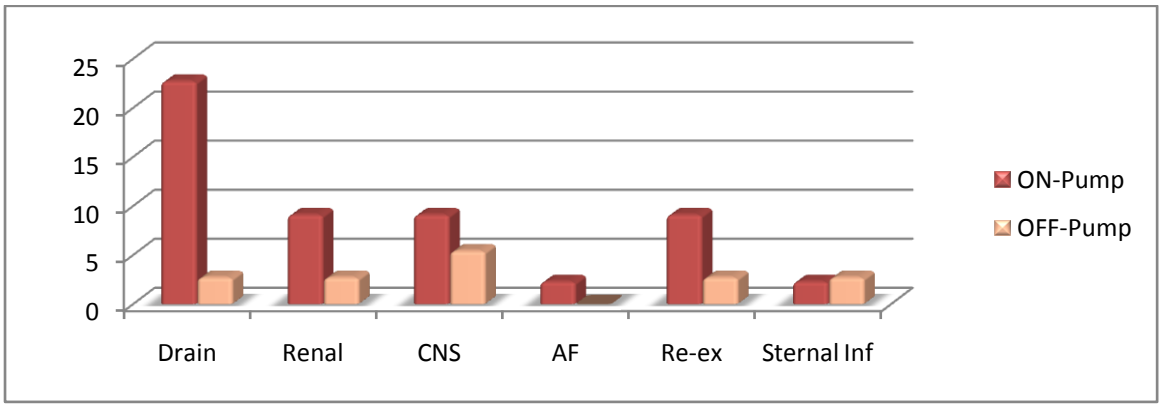
POST OPERATIVE COMPLICATION

	Excessive drainage	Renal	CNS	Arrhythmia	Re-exploration	Deep sternal infection
ON-Pump	10	3	4	1	4	1
OFF-Pump	1	1	2	0	1	1
Converted		1				



DISTRIBUTION OF COMPLICATIONS

	Drainage	Renal	CNS	Arrhythmia	Re-ex	Sternal Inf
ON-Pump	22.7%	`9.09%	9.09%	2.27%	9.09%	2.27%
OFF-Pump	2.7%	2.7%	5.40%	0	2.7%	2.7%



The most common post-operative complication was excess drainage. The average post operative bleeding 466.04ml in both the groups combined. The post average operative drainage in the ON-pump group was 576.13ml and the standard deviation was 394.65ml. The range of bleeding was from 100ml to 1700ml for the ON-Pump group. The average post operative bleeding in the OFF-Pump group was 275ml and the standard deviation was 166.68ml. The range of bleeding was from 100ml to 700ml in the OFF-Pump group. Only two patients in the OFF-Pump group had a post operative bleeding more than 500ml which was the average bleeding in the ON-Pump group.

RENAL DYSFUNCTION

Other complication which was encountered in the study period was post operative renal dysfunction, neurological dysfunction, arrhythmias, deep sternal wound infection and re-exploration for bleeding and other causes like low cardiac output, deterioration of hemodynamics. Post operative renal failure was seen in 10 patients in ON-Pump group and all of them recovered well with medical management, one patient who had poor hemodynamics and expired on the second day, one patient who was converted from OFF-Pump to ON-Pump had renal dysfunction and expired on the third day. One patient in the OFF-Pump group had renal dysfunction had sever left ventricular dysfunction and expired on the second day. In the On-Pump group two patients who developed post operative renal dysfunction had pre-operative elevation of creatinine values which was controlled my medical measures.

NEUROLOGICAL COMPLICATIONS

Four patients in the ON-Pump group developed neurological complications which where Type 1 deficits and improved with medical measures. In the OFF-Pump group two patients had neurological complications and were treated medically. Interestingly patients who had pre-operative carotid artery stenosis did not develop neurological symptoms. Patients operated in the OFF-Pump group, 2 patients had neurological dysfunction both of Type 1 deficit and were treated medically. There was no death reported among patients with neurological complications and patients continued to improve with medical management. Patients were diagnosed as hypoxic encephalopathy and their computer tomography of brain was normal.

ARRHYTHMIA

One patient in the ON-Pump group developed new onset atrial fibrillation and was treated with beta-blocker. Patient was put on Amiodarone 100mg thrice daily regime and during follow up patient stayed in sinus rhythm.

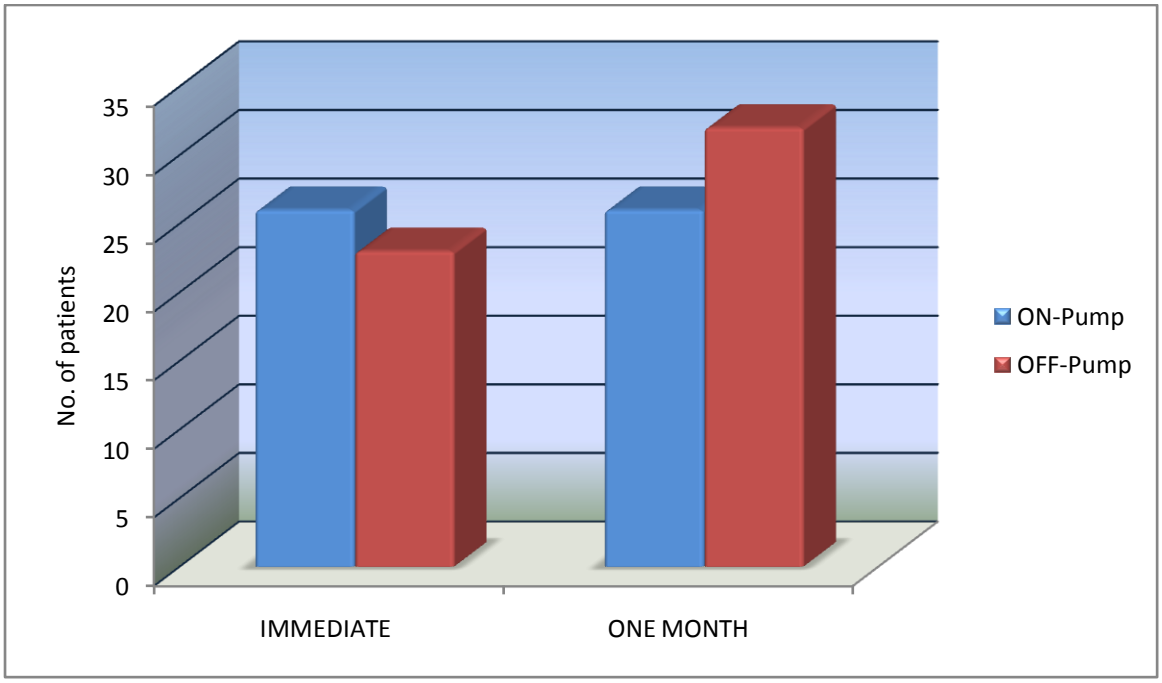
DEEP STERNAL INFECTION

One patient in the On-Pump group developed deep sternal wound and was treated with aggressive debriment and antibiotics. One patient in the OFF-Pump developed infection with Pseudomonas and was treated with Pipracillin-Tazobactum combination. There was no need for rewiring and patients were discharged with sternal corset.

One patient in the ON-Pump group and one patient in the OFF-Pump group had diathermy burns in the buttock and was treated with skin graft to the affect area by plastic surgeons. One patient in the ON-Pump group had leg wound infection at the saphenous vein harvested site due to *S.aureus* and was treated with dressing and antibiotics.

IMPROVEMENT OF EJECTION FRACTION

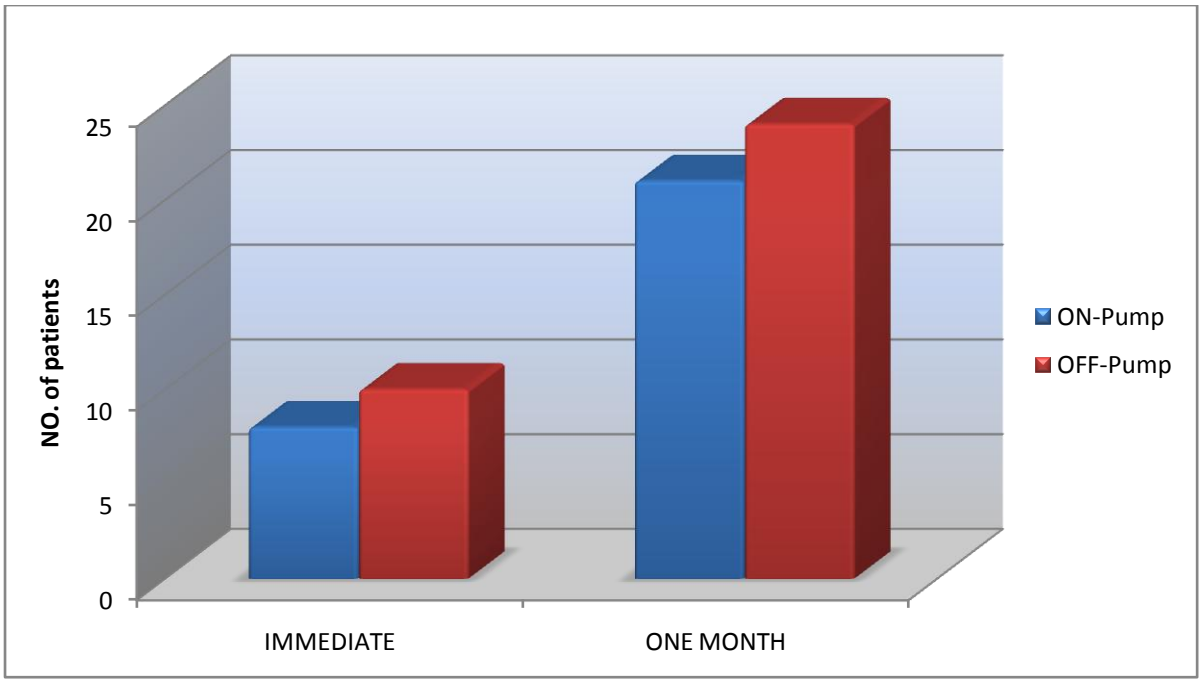
	IMMEDIATE POST OP	ONE MONTH FOLLOW UP
ON-Pump	26	28
OFF-Pump	23	32



Among the 44 patients operated in the ON-Pump group including the converted patients 26 of them had improvement of ejection fraction compared to the pre-operative i.e., 59% patients had improvement in left ventricular function Among the 37 patients operated in the OFF-Pump group 23 patients had improvement in left ventricular function which is 62%. At one month follow up 28 patients in the ON-Pump group and 32 patients in the OFF-Pump group had improvement in left ventricular function which is 63.6% and 86% in the OFF-Pump group.

RETURN TO NORMAL LEFT VENTRICULAR FUNCTION

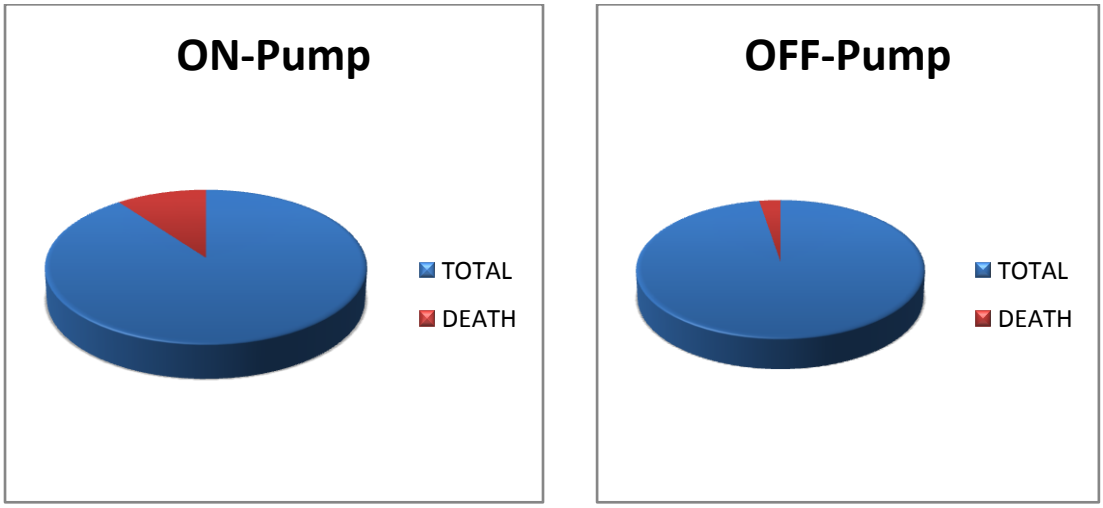
	IMMEDIATE POST OP	ONE MONTH FOLLOW UP
ON-Pump	8	21
OFF-Pump	10	24



The patients had echo at the time of discharge and at follow up after 1 month. The number of patients who had improvement of ejection fraction to normal was charted. In the ON-Pump group 8 patients had improvement of left ventricular ejection fraction to normal value at the time of discharge and 21 patients had returned to normal at one month follow up which was 18.1% and 47.7% respectively. One patient in the ON-Pump group was lost in the follow up had improvement if Ejection fraction at the time of discharge compared to the pre operative value.

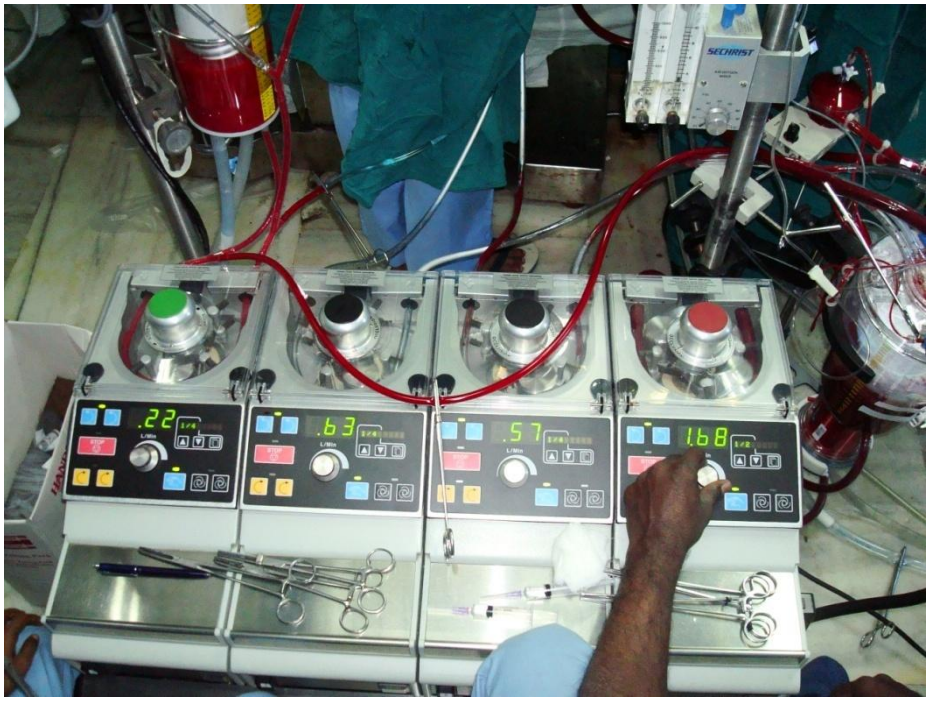
MORTALITY

Patients	ON-Pump	OFF-Pump
Total	44	37
Deaths	5	1

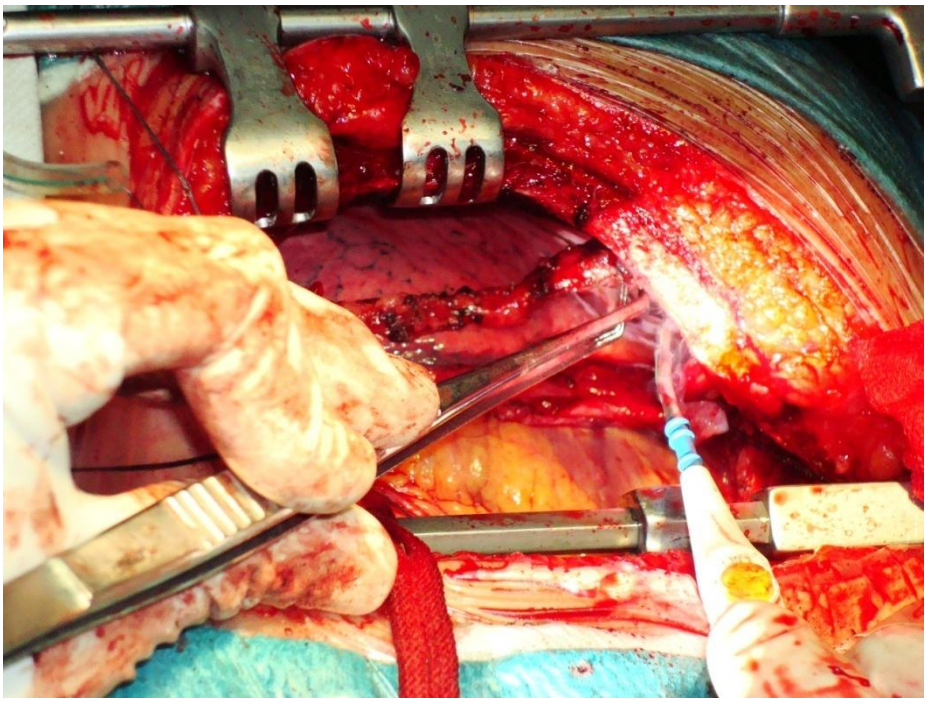


Of the 81 patients in the study, 44 were operated in the ON-Pump group (including 2 patients who were converted from OFF-Pump group to On-Pump group) and 37 were operated in the OFF-Pump group. OF these, there was a mortality of 5 patients (one converted patient) in the ON-Pump group, i.e., 11.36% of ON-Pump patients, while OFF-Pump group had one mortality, i.e., 2.7%.

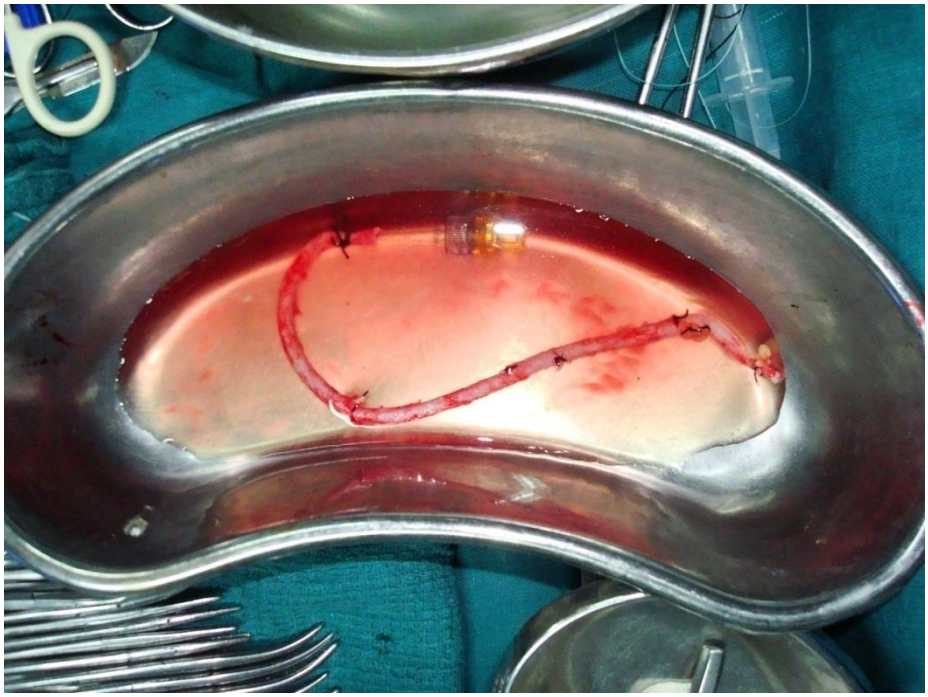
Deaths were due to due to low cardiac output syndrome and multi-organ failure. Of the 5 patients on ON-Pump group, 1 patient was converted and had moderate left ventricular function and 3 patients had severe left ventricular dysfunction. One patient who died in the OFF-Pump group had severe left ventricular dysfunction.



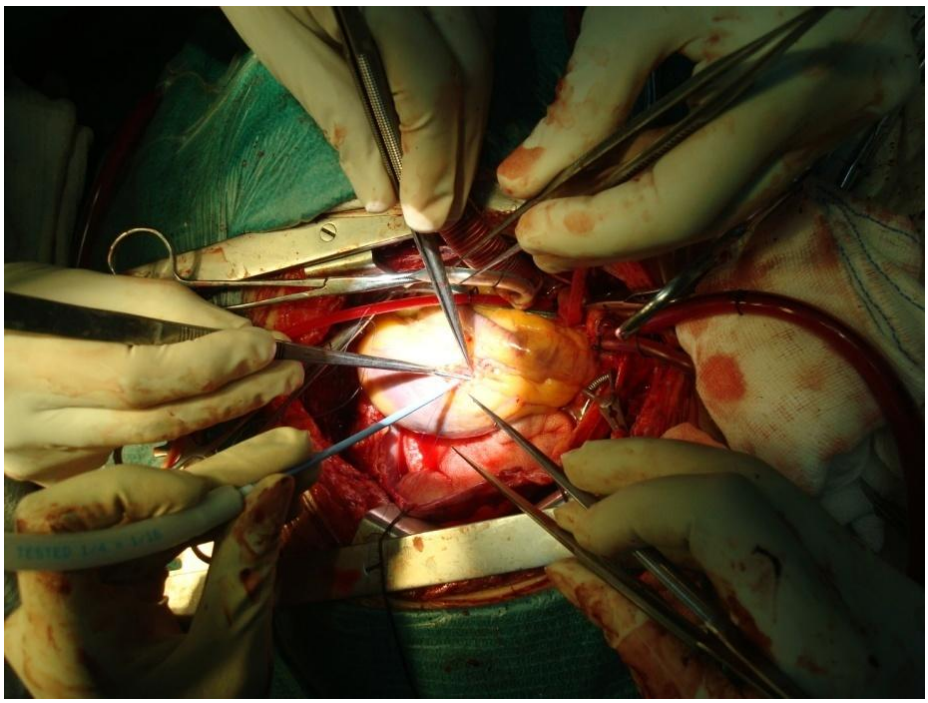
CARDIO-PULMONARY BYPASS MACHINE



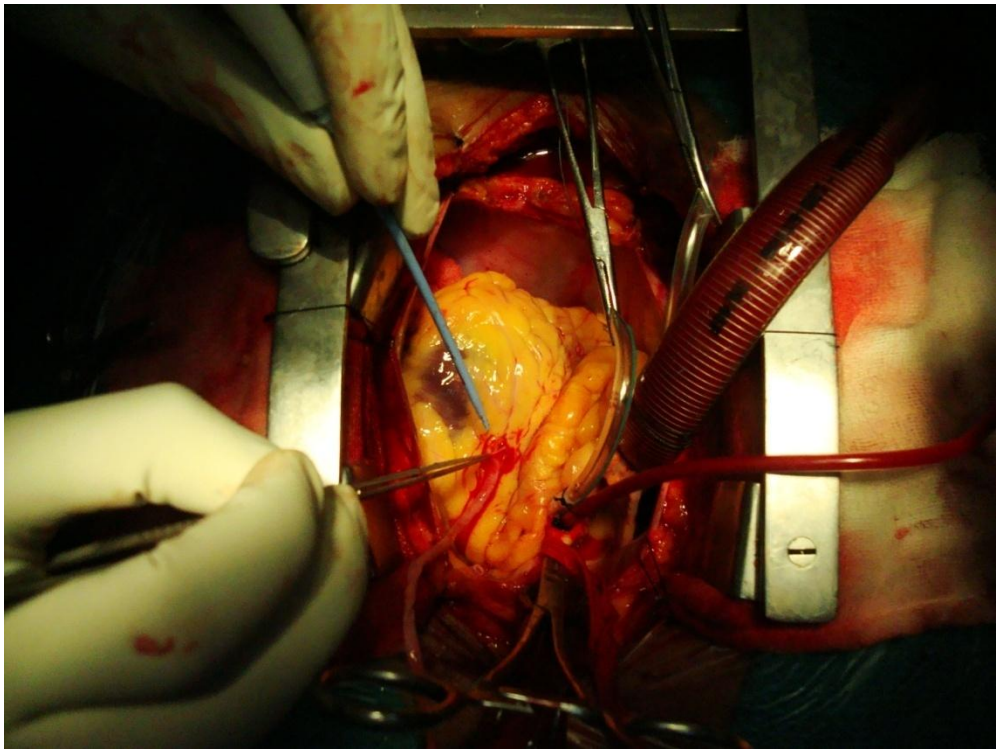
LITA BEING HARVESTED



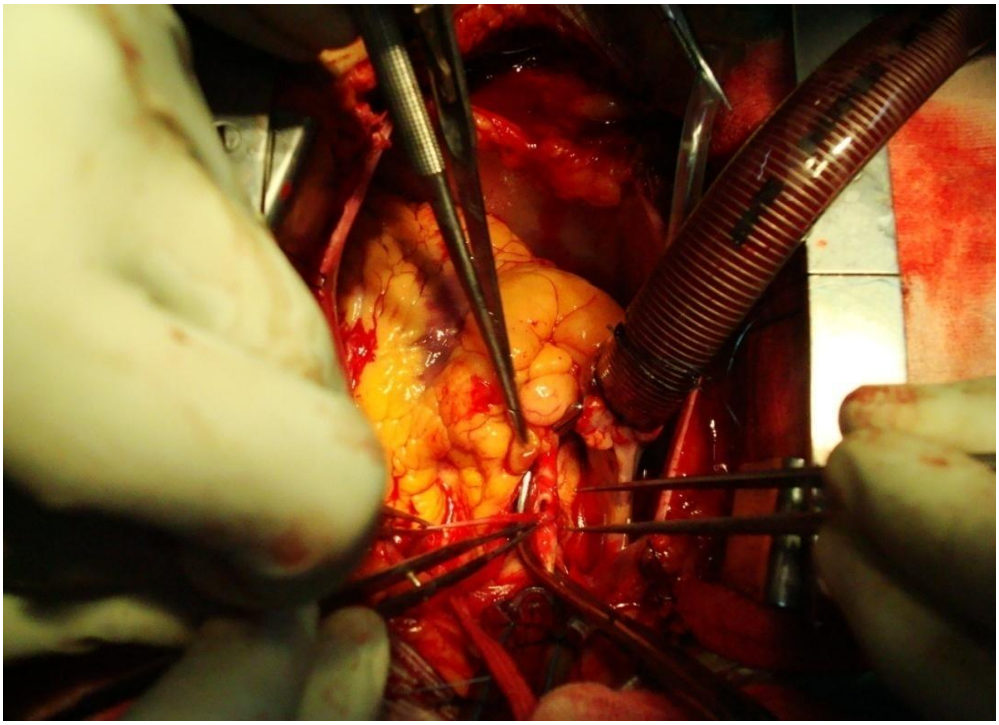
HARVESTED SAPHNOUS VEIN GRAFT



ARTERIOTOMY DONE ON BYPASS

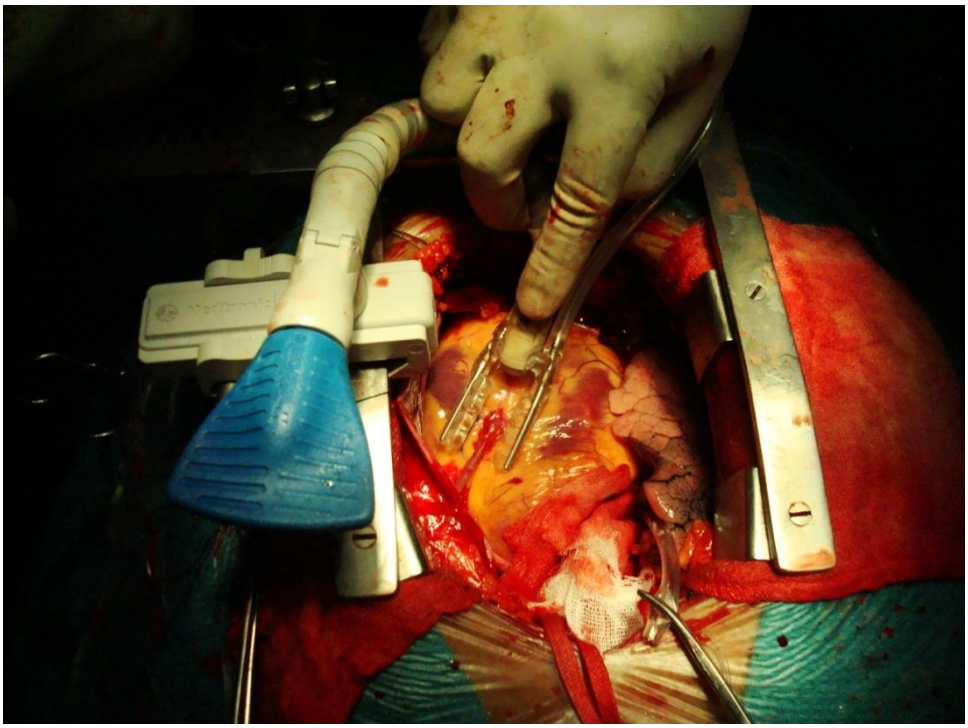


DISTAL.ANASTOMOSIS

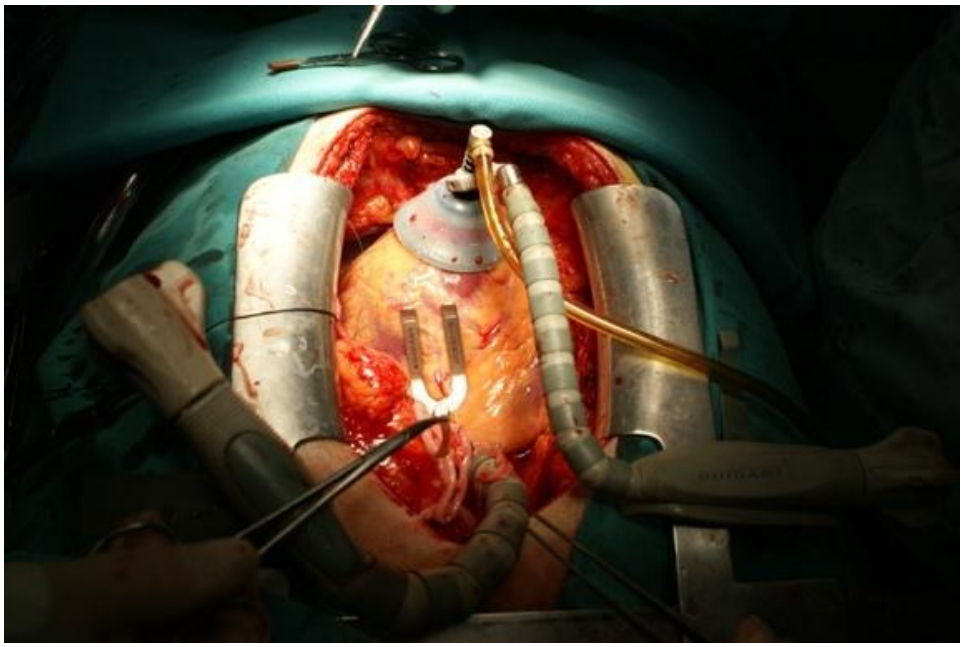


PROXIMAL AORTO-SAPHENOUS ANASTOMOSIS

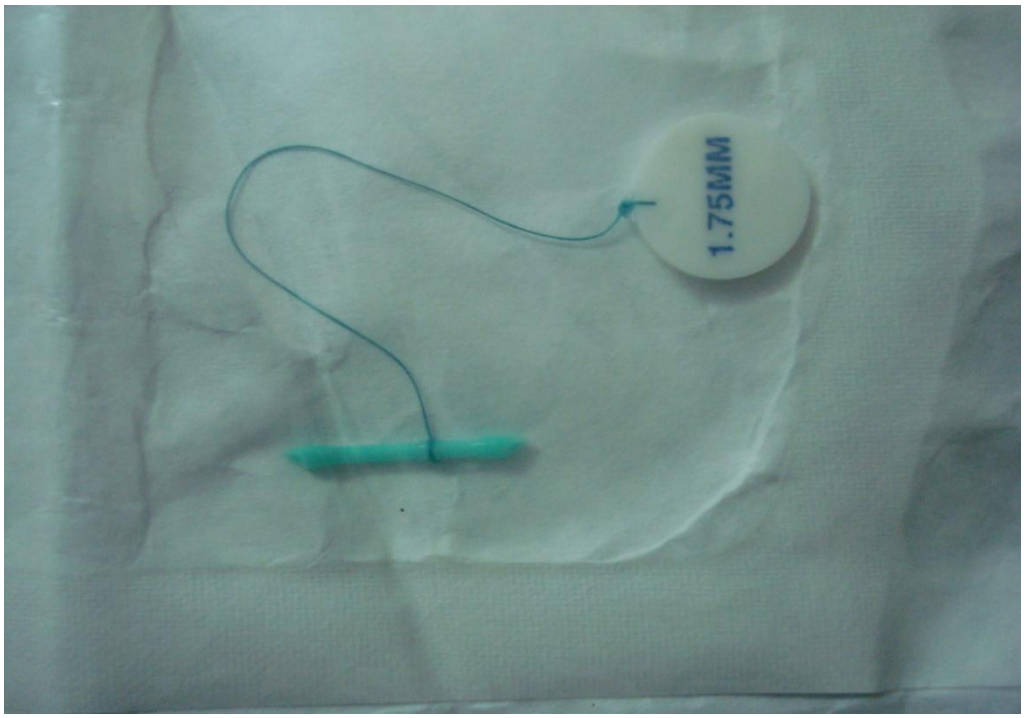
GENERIC STABILIZERS FOR OPCAB



DISTAL ANASTOMOSIS-OPCAB



APEX STABILIZER



INTRA CORONARY SHUNT

DISCUSSION

The ideal conditions for performing coronary artery bypass surgery are cardiopulmonary bypass and cardiac arrest. Cardiopulmonary bypass may increase post operative complications especially in high risk patients[31].

Off pump beating heart surgery for ischemic heart disease has been an innovation of past decades and now recognized as a safe method for myocardial revascularisation. The development of cardiac stabilizers has allowed satisfactory revascularisation of affected vessels. Studies have reported reduced operative morbidity OPCAB[51]. OPCAB is feasible and applicable for patients with depressed left ventricular function.

The present study was a non randomized study, comparative study, the total number of patients were 81, 44 belonging to ON-pump group and 37 belonging to OFF-pump group. The studies used for comparisons, Kamruzzaman et al involved 52 patients [52], 26 in each group. Abraham et al studied 389 patients[53], 262 ON-pump and 119 OFF-pump. Masoumi, et al studied 124 patients[54], 62 in each group.

The mean age in the ON pump group was 53.47 years and 43 years in the OFF pump group. The standard deviation was 10.6 and 6.7 respectively. The two tailed P value was <0.0001-extremely statistically significant. In Masoumi et al study the mean age group was 57.45±9 in ON- pump group and 60.37±8.14 in OFF- pump group.

The male: female sex distribution in Masoumi group was 47:10 in ON- pump group and 49:7 in OFF- pump group[54]. In the present study male gender was dominant and sex distribution was 40:4 in ON- pump group and 35:2 in the OFF-pump group. The sex distribution among ON- pump and OFF- pump group was not statistically significant.

Among the co morbidities diabetes, hypertension chronic obstructive pulmonary disease, hyperlipidemia are given importance. In the present study incidence of diabetes mellitus among the ON- pump group was 43% and 27% in the OFF-pump group. In Masoumi study it was 29% and 23% [54]. P value for diabetes was >0.05.

Hypertension was present in 48% of ON-pump and 52% of OFF-pump group in Masoumi et al study[54]. In Abraham et al study it was 17.9% in the ON-pump group and 20.2% in the OFF-pump group. In the present study it was 47.72% in the ON-pump group and 37.83% in the OFF-pump group. The P value was not found to be statistically significant.

Hyperlipidemia was present in 46% of ON-pump patients and 38% of OFF-pump group, while it was 42% and 42% respectively in Masoumi study.

Among the pre operative patients, chronic obstructive pulmonary disease in the ON-pump group was 11.36% and 10.8% in the OFF-pump group. The two were not significant. The pre operative renal dysfunction was present in 4.5% of the ON-pump group and 5.4% of the OFF-pump group.

The mean pre operative ejection fraction was 44.09% and 47.08% in the ON-pump and OFF-pump groups respectively. In the present study, the P value was 0.0583 which was not quite significant. With regard to the other studies, in Masoumi et al [54] study it was 35% and 35%. In Abraham et al study[53] it was 30.9% and 30.8% in the ON- pump and OFF-pump group respectively.

The average number of grafts used in other studies such as Masoumi et al study[54] was 3.42±0.86 in the ON-pump group and 3.09±0.41 in the ON-pump and

OFF-pump groups respectively. In Abraham et al [53] study it was 3.51 and 1.80 in the ON-pump and OFF-pump groups respectively. In the present study the average number of grafts was 2.52 in the ON-PUMP GROUP and 1.75 in the OFF-pump group which is not statistically significant.

With regard to the conduit used in the Masoumi et al [54] study internal thoracic artery was used in all the coronary artery revascularisation procedures. In Abraham et al [53] study , in the ON-pump group , internal thoracic artery was used in 92% of the patients and in the OFF-pump group, it was used in 96% of the patients. In the present study internal thoracic artery was used in 55% of patients in the ON-pump group and 83% of patients in the OFF-pump group. P value is not significant.

In the statistical analysis of the post operative period the average ventilation time was 15.5±10.6 hours in the ON-pump group and 11.94±8.4 hours in the OFF-pump group. The P value was 0.135 and not statistically significant. The ICU stay was 3.13 days in the ON-pump group and 2.18 days in the OFF-pump group. The total average hospital stay in the ON-pump and OFF-pump groups was 9±2.1 days and 7.75±2 days respectively. In the Abraham et al [53] study, the average length of hospital stay was 10.0 days in ON-pump group and 8.4 days in OFF-pump group. In the Masoumi et al [54] study, average ICU stay was 5.2±6 days and 2.9±2.5 days in the ON-pump and OFF-pump groups respectively. The average hospital stay was 12.2±5.7 days and 9.4±3.3 days in the ON-pump and OFF-pump groups respectively.

While analyzing the post operative complications, it was noted that excess drainage was the most common complication in the present study. The other complications were renal failure, neurological complications and deep sternal wound infection. The average amount of drainage in the study was 576.13±394.6ml in the

ON-pump group and 333.78±166.6ml in the OFF-pump group. The standard error of the mean was 59.49 and 27.38 respectively. The P value was 0.0008 and is statistically significant. In the Abraham et al study[53], excessive bleeding was noted in 4.2% in ON-pump group and 1.7% in OFF-pump group. In the present study it was 22.7% in ON-pump group and 2.7% in the OFF-pump group.

Regarding other complications, renal failure was seen in 9.09% and 2.7% of patients in the ON-pump and OFF-pump groups respectively. The neurological complications were noticed in 9.09% and 5.40% of patients in the ON-pump and OFF-pump groups respectively. Arrhythmia was seen in 1 patient which is 2.27%. The rate of re exploration was 9.09% in the ON-pump group, while it was 2.7% in the OFF-pump group which is statistically significant. Sternal wound infection was seen in 2.27% of ON-pump operated patients and 2.7% of OFF-pump operated patients. It is statistically not significant.

On analyzing the patients improvement in left ventricular ejection fraction 26 patients had improved at the time of discharge in the ON-pump group and 23 patients had improvement in OFF-pump group which was 59% and 62% respectively. The improvement in ejection fraction during follow up after 1 month period was noted in 28 patients (63.6%) and 32 (86%) patients in the ON-pump and OFF-pump groups respectively. The P value was significant among the two groups. In the Kamruzzaman et al study[52] , the ejection fraction at baseline (at time of surgery) was 34.2±3.7 and after 6 months was 46.2±5.2. P value<0.001-significant.

Analyzing the statistics on mortality, it was found that mortality in the ON-pump group was 11.36% and 2.7% in the OFF-pump group. In comparison with other studies , Masoumi et al[54] had 6.45% death in the ON-pump group and nil mortality in

the OFF-pump group. Abraham et al[53] had 4.6% mortality in the ON-pump group and 5.9% in the OFF-pump group. With regard to mortality, the mortality in ON-pump is compounded by the fact that OFF-pump cases that are converted to ON-pump is finally included in the ON-pump group and the proportion of complications might be due to the increased morbidity due to reasons for conversion from OFF-pump to ON-pump group[53].

	Present study		**Masoumi, et al.**		**Abraham, et al.**		**Kamruzzaman, et al.**	
	ON-Pump	**OFF-Pump**	**ON-Pump**	**OFF-Pump**	**ON-Pump**	**OFF-Pump**	**ON-Pump**	**OFF-Pump**
AGE	**53.47±10**	**43±6**	57.45±9	60.37±8	65.3	68	57.5±5	55.5±4.5
SEX	**44:10**	**35:2**	47:10	49:7	200:62	87:32	51:11	52:10
Co morbidities								
DM	**43%**	**27%**	29%	23%	0	0	-	-
HT	**47.72%**	**37.83%**	48%	52%	17.9%	20.2%	-	-
Hyperlipidemia	**46%**	**38%**	42%	42%	-	-	-	-
Pre OP EF%	**44.09%**	**47.08%**	35%	35%	30.9%	30.8%	33.2±3.8%	35.2±3.2%
Conduit - ITA	**55%**	**83%**	99%	99%	92%	96%	-	-
Grafts	**2.52**	**1.75**	3.42±0.8	3.09±0.4	3.51	1.80	-	-
Post OP Ventilation in hrs	**15.5±10.6**	**11.9±8.4**	-	-	-	-	-	-
ICU Stay in days	**3.13**	**2.18**	5.2±6	2.9±2.5	-	-	-	-
Hosp Stay in days	**9±2.1**	**7.75±2**	12.2±5.7	9.4±3.3	10	8.4	-	-
Complications								

Post Op Bleeding in ml	**576.13±394**	**333.78±166**	680	550				
Excess bleeding	**22.7%**	**2.7%**	-	-	4.2%	1.7%	-	-
Renal dysfunction	**9.09%**	**2.7%**	0	10%	1.9%	5%	-	-
Sternal Infection	**2.27%**	**2.7%**	0	0	3.1%	3.4%	-	-
CNS dysfunction	**9.09%**	**5.4%**	-	-	0.4%	0.8%	-	-
Arrhythmia	**2.27%**	**0**	37%	3%	-	-	-	-
EF% at discharge	**46.2%**	**49.5%**	-	-	-	-	34.2±3.7%	34.9±1%
EF% at 1 month	**51.8%**	**55.3%**	-	-	-	-	-	-
EF% at 6 months	**-**	**-**	-	-	-	-	46.2±5.2%	48.5±3%
Mortality	**11.36%**	**2.7%**	6.45%	0	4.6%	5.9%	-	-

INTERPRETAION OF RESULTS

The incidence of coronary artery disease seems to be more in males than females in the local population.

The peak incidence of coronary artery disease with left ventricular dysfunction is seen in the 41 to 60 years age group followed by other age groups. This distribution is in contrast with the western population where prevalence of coronary artery disease is more in the sixth decade of life. This indicates that demographically Indians are prone for coronary artery disease at a younger age.

Diabetes and hypertension are the two most common co-morbid conditions seen in the Indian population, followed by chronic obstructive lung disease. The presence of pre operative renal dysfunction increases the propensity for post operative renal failure/morbidity.

Triple vessel disease is more prevalent among patients with left ventricular dysfunction compared to double vessel disease or single vessel disease.

Most of the patients presented with mild left ventricular dysfunction represented as reduced ejection fraction followed by moderate left ventricular dysfunction and severe dysfunction.

The most commonly used conduits were left internal thoracic artery and saphenous vein graft in combination. Saphenous vein graft alone was used when the patient was hemodynamically unstable or in emergency situations.

During the post operative period, ventilation time was less in the OFF-pump group. The duration in Intensive care unit as well as the total hospital stay was marginally less compared to the ON-pump group.

Of the post operative complications, excessive drainage was the most common complication and significant amount of blood loss was noticed in the ON-pump surgeries. OFF-pump was beneficial as far as post operative bleeding is concerned. The rate of re-exploration was more in ON-pump surgeries. Other less common complications were renal dysfunction, neurological dysfunction especially type I, sternal wound infection and development of new arrhythmias.

There was significant improvement in the ejection fraction in patients who were completely revascularized and over a period of one month, ejection fraction improved significantly compared to pre operative status.

The mortality among the groups was seen in severe left ventricular dysfunction that were operated ON-pump. Conversion from OFF-pump to ON-pump surgery carries a high morbidity and mortality. OFF-pump surgery offers some benefit over ON-pump surgery for patients with severe left ventricular dysfunction.

CONCLUSIONS

To conclude the study, OFF-pump surgery is a safe method of coronary revascularisation in patients with left ventricular dysfunction. There appears to be less mortality and morbidity in the OFF-pump surgery.

OFF-pump surgery alleviates the complication of cardiopulmonary bypass which is significant for high risk patients with low ejection fraction.

OFF-pump surgery reduces the ventilation time, intensive care stay and promotes early discharge from the hospital. There is significant improvement of ejection fraction compared the to pre operative status and patients have functional improvement.

However, fewer numbers of vessels were grafted in the OFF-pump group and this needs to improve. Probably with the upcoming better stabilizers, this problem can be alleviated in future.

Despite the shortcoming of the methodology, small sample size and non-randomized study, the study adds to the recommendations of other numerous studies the benefits of OFF-pump coronary artery surgery in patients with left ventricular dysfunction.

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ANNEXURE – I

PROFORMA

Patient Name :

Age /Sex :

IP. No :

Address :

Date of Admission :

Date of Surgery :

Date of Discharge :

Chief complaints :

Cardiac Symptoms :

Past History :

General Examination : Pallor/ Clubbing/ Cyanosis / Jaundice / Pedal Edema

PR: BP:

CARDIOVASCULAR SYSTEM :

RESPIRATORY SYSTEM :

INVESTIGATIONS

Hb: PCV: ESR:

Urea : Creatinine :

Na+ : K+ : ECG :

CHEST X-RAY :

PRE OP ECHO (TTE) :

CORONARY

ANGIOGRAM :

DIAGNOSIS :

SURGERY :

No: of grafts :

Types of grafts :

Bypass time :

Surgery time :

ACT post operative :

POSTOPERATIVE :

Drainage :

Ventilation Time :

ICU Stay :

Hospital Stay :

COMPLICATIONS :

Renal :

Neurological :

Arrhythmias :

Re-opening :

Sternal Wound Infection :

OUTCOME :

POST OP ECHO :

Discharged / Prolonged stay / Expired

FOLLOW UP ECHO :

ANNEXURE – II

ABBREVIATIONS

AF	-	Atrial Fibrillation
ACT	-	Activated Clotting Time
CAD	-	Coronary Artery Disease
CABG	-	Coronary Artery Bypass Grafting
COPD	-	Chronic Obstructive Pulmonary Disease
CNS	-	Central Nervous System
D	-	Diagonal Branch
LV	-	Left Ventricle
LM	-	Left Main Artery
LAD	-	Left Anterior Descending Artery
LCX	-	Left Circumflex Artery
LITA	-	Left Internal Thoracic Artery
MI	-	Myocardial Infarction
OM	-	Obtuse Marginal
RCA	-	Right Coronary Artery
EF	-	Ejection Fraction
OPCAB	-	Off-pump Coronary artery bypass
PDA	-	Posterior Descending Artery
PLB	-	Postero-lateral Segment Artery

S.no	Name	Age	Sex	IP no	Diagnosis	Co-morbidities					System affected	Pre Op EF%			Group	system grafted	grafts used	Conduit Used	Remarks	Surgery time	Post Op Blood loss	ventilation time	ICU stay	Hospital stay	Complication							Post Op EF%	Outcome	Follow up EF%
						COPD	Renal	DM	Carotid disease	HT		Mild	Mod	Sev											Renal	MI	CNS	Arrhythimias	Re-exploration	Sternal infection	Others			
1	Rajasekar	43yrs	M	32572	CAD - DVD						LAD,OM1	54%			B	2	2	SVG	subclavian stenosis	5hrs	250ml	5hrs	3days	10days								50%	discharged	55%
2	Sumathi	47yrs	F	29371	CAD - TVD					Y	LAD,OM3,RCA		44%		B	3	3	LIMA,SVG		6hrs	250ml	12hrs	3days	10days								45%	discharged	48%
3	Raja	50yrs	M	25030	CAD - DVD			Y			LAD,RCA			28%	B	2	2	LIMA,SVG		6hrs	600ml	12hrs	5days	15days			Y				Bed sore	40%	discharged	45%
4	Varadharajan	52yrs	M	14951	CAD - TVD					Y	LAD,OM1,OM2,RCA	47%			A	3	4	LIMA,SVG		7hrs	300ml	12hrs	5days	12days								37%	discharged	45%
5	Ravichandran	51yrs	M	1E+05	CAD - TVD					Y	LAD,OM,RCA	50%			A	2	2	LIMA,SVG		6hrs	250ml	12hrs	3days	10days								55%	discharged	55%
6	Loganathan	38yrs	M	28388	CAD - SVD			Y			LAD		44%		A - converted	1	1	SVG	LIMA - iotrogenic injury	7hrs	300ml	72hrs	3days	-	Y		Y					-	expired	-
7	Saravanan	41yrs	M	26781	CAD - TVD						LAD,OM1,RCA	50%			A	3	3	LIMA,SVG		6hrs	400ml	13hrs	3days	10days								45%	discharged	50%
8	Yasin	55yrs	M	26590	CAD - DVD						LAD,RCA	54%			B	2	2	LIMA,SVG		5hrs	200ml	12hrs	3days	10days								40%	discharged	60%
9	Pradeep	56yrs	M	24588	CAD - SVD						LAD,RCA	50%			B	1	1	LIMA		4hrs	300ml	8hrs	3days	10days								55%	discharged	56%
10	Kajasherif	44yrs	M	20428	CAD - DVD	Y				Y	LAD,OM2	50%			A	2	2	SVG	unstable hemodynamics	5hrs	800ml	15hrs	3days	16days	Y							55%	discharged	55%
11	Sathyamoorthy	48yrs	M	24335	CAD - TVD	Y		Y		Y	LAD,OM1,RCA	48%			B	3	3	LIMA,SVG		4.5hrs	850ml	8hrs	3 days	10 days								45%	discharged	55%
12	Jeyaraman	49yrs	M	98776	CAD - SVD						LAD		40%		B	1	1	LIMA		3hrs	150ml	12hrs	3 days	10days								48%	discharged	60%
13	Mani	75yrs	M	1E+05	CAD - SVD			Y			LAD	50%			A	1	1	LIMA		3hrs	600ml	17hrs	3 days	14days								37%	discharged	48%
14	Saroja	62yrs	F	70050	CAD - TVD	Y		Y		Y	LAD,D1,OM2,PDA		37%		A	2	2	LIMA,SVG	D1 - thin vessel	7hrs	850ml	22hrs	5days	12days								40%	discharged	50%
15	Shek Mohammed	40yrs	M	82186	CAD - SVD					Y	LAD	54%			B	1	1	LIMA		4.5hrs	100ml	15hrs	7days	15days						Y		48%	discharged	50%
16	Velu	38yrs	M	1E+05	CAD - DVD						LAD,OM1,RCA			32%	A	3	3	SVG		5hrs	200ml	15hrs	3days	11days								30%	discharged	38%
17	Nagarajan	58yrs	M	81262	CAD - TVD		Y	Y		Y	LAD,OM1,OM3,RCA		40%		A	2	2	LIMA,SVG		5hrs	900ml	12hrs	3days	15days	Y		Y					50%	discharged	55%
18	Rajendran	76yrs	M	71057	CAD - DVD			Y		Y	LAD,D1,OM1		42%		A	2	2	LIMA,SVG	OM1 - non graftable	4hrs	150ml	10hrs	3days	10days								45%	discharged	55%
19	Arumugam	56yrs	M	76549	CAD - SVD	Y					LAD	50%			B	1	1	LIMA		3hrs	250ml	5hrs	2days	10days								50%	discharged	65%
20	Subramani	55yrs	M	78811	CAD - DVD		Y	Y			LAD,OM2	51%			B	2	2	LIMA,SVG		5hrs	400ml	5hrs	2days	9days								50%	discharged	55%
21	Kumaravelu	40yrs	M	74593	CAD - TVD						LAD,OM1,PDA,PLB		44%		A	3	4	LIMA,SVG		6hrs	300ml	14hrs	3days	10days								55%	discharged	55%
22	Nagarajan	66yrs	M	67314	CAD - DVD						LAD,RCA	50%			A	2	2	LIMA,SVG		4hrs	350ml	12hrs	3days	15days								45%	discharged	50%
23	Vijayan	40yrs	M	81630	CAD - TVD						LAD,D1,RCA		44%		A	3	3	LIMA,SVG		6hrs	1300ml	12hrs	3days	12days					Y			50%	discharged	55%
24	Alagarswamy	65yrs	M	65490	CAD - TVD						LAD,D1,PLB	50%			A	3	3	LIMA,SVG		5hrs	450ml	12hrs	3days	10days								55%	discharged	57%
25	Muruganandan	47yrs	M	65213	CAD - DVD			Y		Y	LAD,OM1	54%			B	2	2	LIMA,SVG		6hrs	500ml	12hrs	3days	10days								60%	discharged	55%
26	Irudhayaraj	65yrs	M	57735	CAD - DVD		Y				LAD	51%			B	1	1	LIMA		3hrs	200ml	5hrs	3days	10days								55%	discharged	55%
27	Karthigeyan	52yrs	M	73177	CAD - DVD						LAD,OM1	52%			B	2	2	SVG		4hrs	500ml	12hrs	3days	10days								35%	discharged	55%
28	Natrajan	60yrs	M	58104	CAD - TVD		Y	Y		Y	LAD,OM1,OM2,PAD,PLB		42%		A	4	4	SVG	PLB - non graftable	7hrs	650ml	15hrs	3days	20days	Y			AF					45%	discharged	50%
29	Marimuthu	64yrs	M	57114	CAD - TVD						LAD,OM1,PDA		40%		A	2	2	SVG		5hrs	300ml	12hrs	3days	10days								47%	discharged	60%
30	Kandaswamy	50yrs	M	71341	CAD - SVD						LAD,D1	46%			B	2	2	LIMA,SVG		5hrs	200ml	5hrs	3days	10days								50%	discharged	55%
31	Kemppaiah	36yrs	M	60525	CAD - DVD	Y					LAD,RCA	48%			B	2	2	LIMA,SVG		5hrs	300ml	12hrs	3days	10days								51%	discharged	52%
32	Raja	50yrs	M	25030	CAD - TVD						LAD,OM3,RCA	52%			A	1	1	SVG	OM1 - non graftable	3hrs	200ml	10hrs	2days	10days								53%	discharged	42%
33	Nagaraj	48yrs	M	1E+05	CAD - SVD			Y			LAD	48%			A	1	1	SVG	LIMA - injured	4hrs	1800ml	16hrs	5days	12days					Y			51%	discharged	57%
34	George	51yrs	M	1665	CAD - DVD			Y			LAD,OM1	45%			A	2	2	LIMA,SVG		6hrs	750ml	15hrs	3days	10days							Leg wound infection	40%	discharged	47%
35	Daniel babu	42yrs	M	2132	CAD - DVD			Y			LAD,OM3	45%			A - converted	1	1	SVG	OM3 - thin vessel	4hrs	300ml	12hrs	3days	10days								50%	discharged	52%
36	Kamaraj	44yrs	M	76912	CAD -TVD						LAD,RCA,OM1			22%	B	2	2	SVG	OM1 - non graftable	5hrs	500ml	48hrs	2days	-	Y				Y			-	Expired	-
37	Naresh Kumar	53yrs	M	54247	CAD - TVD			Y		Y	LAD,OM2,RCA			30%	A	3	3	LIMA,SVG		5hrs	800ml	13hrs	4days	12days								30%	discharged	41%

38	Murgan	47yrs	M	53039	CAD - DVD			Y		Y	LAD,RCA		44%		B	2	2	LIMA,SVG		4hrs	200ml	16hrs	3days	12days								45%	discharged	50%
39	Kumaraswamy	55yrs	M	58099	CAD - TVD					Y	LAD,RCA,OM2	46%			A	3	3	LIMA,SVG		6hrs	300ml	14hrs	3days	10days								55%	discharged	55%
40	Mathivanan	47yrs	M	68940	CAD - TVD			Y		Y	LAD,RCA,OM1		35%		A	3	3	SVG		7hrs	450ml	14hrs	3days	14days			Y					40%	discharged	-
41	Chandra	60yrs	F	51049	CAD - TVD					Y	LAD,RCA,OM1,D1		44%		A	3	4	SVG	LIMA - poor flow	6hrs	400ml	12hrs	3days	10days								45%	discharged	57%
42	Vijaya kumar	47yrs	M	48592	CAD - SVD						LAD		48%		B	1	1	LIMA		4hrs	400ml	12hrs	3days	10days								55%	discharged	56%
43	Abdul Kadhar	63yrs	M	77735	CAD - TVD	Y		Y	Y - minimal	Y	LAD,D1,OM1,RCA	45%			A	3	3	SVG		6hrs	500ml	12hrs	3days	19days							bed sore	45%	discharged	48%
44	Nagaraj	46yrs	M	44337	CAD - DVD						LAD,RCA	53%			A	2	2	LIMA,SVG		5hrs	450ml	12hrs	3days	10days								50%	discharged	60%
45	Boopalan	60yrs	M	53501	CAD - TVD			Y		Y	LAD,RCA,OM1	50%			B	2	3	SVG		5hrs	700ml	12hrs	3days	11days								54%	discharged	55%
46	Ramesh	44yrs	M	48702	CAD - DVD			Y			LAD,RCA	52%			B	2	2	LIMA,SVG		4hrs	300ml	12hrs	3days	10days								50%	discharged	65%
47	Sathish kumar	37yrs	M	57747	CAD - TVD			Y			LAD,RCA,OM1		44%		A	3	3	LIMA,SVG		6hrs	350ml	12hrs	3days	10days								49%	discharged	55%
48	Arul doss	51yrs	M	48848	CAD - DVD					Y	LAD,RCA	54%			A	1	1	LIMA		5hrs	350ml	12hrs	3days	10days								55%	discharged	60%
49	Radha krishnan	54yrs	M	62923	CAD - SVD						LAD	46%			B	1	1	LIMA		5hrs	300ml	5hrs	3days	10days								50%	discharged	56%
50	Pon Pandi	62yrs	M	57553	CAD - TVD			Y			LAD,RCA,OM3		44%		A	3	3	LIMA,SVG		7hrs	750ml	15hrs	1day	-								-	expired	-
51	Dayalan	55yrs	M	45915	CAD - SVD						LAD	54%			B	1	1	LIMA		4hrs	350ml	12hrs	3days	10days			Y					60%	discharged	57%
52	Rajan	48yrs	M	56107	CAD - SVG						LAD		47%		B	1	1	LIMA		4hrs	250ml	6hrs	3days	10days								55%	discharged	59%
53	Subramani	53yrs	M	63753	CAD - DVD			Y		Y	LAD,RCA	50%			B	1	1	LIMA	RCA - diffuse disease	5hrs	400ml	12hrs	3days	10days								50%	discharged	57%
54	Om prakash	54yrs	M	49578	CAD - DVD						LAD,OM2	53%			B	2	2	LIMA,SVG		5hrs	300ml	12hrs	3days	10days								55%	discharged	60%
55	Saraswathy	55yrs	F	46994	CAD - TVD				Y		LAD,RCA,D1,OM1	53%			A	3	3	SVG		6hrs	350ml	12hrs	3days	11days								55%	discharged	55%
56	Ganesan	62yrs	M	51911	CAD - TVD			Y	Y		LAD,OM1,RCA			27%	A	3	3	LIMA,SVG		6hrs	500ml	12hrs	3days	10days								32%	discharged	40%
57	Periyaswamy	62yrs	M	51829	CAD - DVD	Y		Y	Y	Y	LAD,RCA			28%	B	2	2	LIMA,SVG		5hrs	200ml	40hrs	4days	15days								48%	discharged	55%
58	Sekar	38yrs	M	38447	CAD - SVD					Y	LAD	52%			B	1	1	LIMA		3hrs	300ml	5hrs	2days	10days								55%	discharged	55%
59	Dhandapani	46yrs	M	61347	CAD - TVD					Y	LAD,OM3		42%		A	2	2	LIMA,SVG		5hrs	1700ml	12hrs	3days	10days				Y				45%	discharged	50%
60	Rajakumari	45yrs	F	46247	CAD - TVD			Y		Y	LAD,OM3,RCA	53%			A	3	3	SVG		6hrs	400ml	12hrs	3days	10days								40%	discharged	50%
61	Ahamed Khan	59yrs	M	51377	CAD - TVD					Y	LAD,OM1,RCA	54%			B	3	3	LIMA,SVG		7hrs	500ml	12hrs	3days	10days								45%	discharged	55%
62	Vadivelu	61yrs	M	44889	CAD - SVD						LAD	54%			B	1	1	SVG		4hrs	250ml	12hrs	3days	10days								50%	discharged	55%
63	Vetriselvan	43yrs	M	39377	CAD - TVD			Y		Y	LAD,OM1,RCA			25%	A	2	2	SVG		6hrs	1000ml	50hrs	2days	-	Y	Y		Y				-	expired	-
64	Shanmugam	68yrs	M	57932	CAD - TVD						LAD,OM1,RCA	50%			A	3	3	LIMA,SVG		6hrs	400ml	12hrs	3days	10days								45%	discharged	55%
65	Vimalanathan	53yrs	M	54267	CAD - DVD						LAD,RCA	50%			B	2	2	LIMA,SVG		4hrs	600ml	12hrs	3days	10days								55%	discharged	65%
66	Govindarajan	50yrs	M	45906	CAD - TVD					Y	LAD,RCA,OM2	52%			A	3	3	LIMA,SVG		6hrs	350ml	12hrs	3days	11days								60%	discharged	55%
67	Padma	73yrs	M	58298	CAD - TVD	Y		Y		Y	LAD,RCA,OM1	54%			A	3	3	LIMA,SVG		6hrs	200ml	12hrs	3days	10days								50%	discharged	55%
68	Sajith Khan	47yrs	M	47067	CAD - DVD						LAD,RCA	50%			B	2	2	LIMA,SVG		4hrs	300ml	12hrs	2days	10days								55%	discharged	57%
69	Mani rani	47yrs	M	37226	CAD - DVD						LAD,RCA		42%		B	2	2	SVG		5hrs	300ml	10hrs	3days	10days								30%	discharged	50%
70	Afta banu	62yrs	M	49480	CAD - TVD				Y		LAD,RCA,OM3	48%			A	3	3	SVG	unstable hemodynamics	6hrs	900ml	12hrs	3days	12days								45%	discharged	55%
71	Srinivasan	45yrs	M	27354	CAD - SVD						LAD		40%		B	1	1	LIMA		3hrs	200ml	6hrs	3days	10days								50%	discharged	50%
72	Selvanaki	45yrs	F	45886	CAD - DVD					Y	LAD,RCA	46%			B	2	2	LIMA,SVG		5hrs	400ml	10hrs	3days	10days								45%	discharged	45%
73	Ragunathan	46yrs	M	46259	CAD - TVD			Y		Y	LAD,OM1,RCA		38%		A	3	3	SVG		7hrs	1500ml	15hrs	3days	21days						Y		37%	discharged	45%
74	Dhanapal	46yrs	M	40777	CAD - TVD					Y	LAD,OM1,RCA	44%			B	2	3	LIMA,SVG		5hrs	100ml	12hrs	3days	10days								50%	discharged	65%
75	Mariaprakasam	40yrs	M	44964	CAD - TVD			Y		Y	LAD,RCA,OM1	43%			A	3	3	LIMA,SVG		5hrs	750ml	12hrs	3days	10days			Y					45%	discharged	55%
76	Shankar	66yrs	M	37167	CAD - SVD						LAD		48%		A	1	1	SVG	LIMA - diseased	4hrs	400ml	12hrs	3days	10days								50%	discharged	50%
77	Murugesan	60yrs	M	34747	CAD - TVD					Y	LAD,RCA,OM1	48%			A	3	3	SVG		5hrs	550ml	12hrs	3days	10days								40%	discharged	55%
78	Mohamed yacub	45yrs	M	29952	CAD - TVD						LAD,OM3,PDA,PLB			28%	A	2	3	SVG		8hrs	100ml	-	-	-								-	expired	-
79	Chandran	46yrs	M	41609	CAD - DVD			Y		Y	LAD,RCA		44%		B	2	2	LIMA,SVG		4hrs	150ml	12hrs	3days	10days								55%	discharged	55%
80	Dhanasekaran	57yrs	M	29765	CAD - TVD	Y		Y			LAD,RCA,OM1			34%	A	3	3	SVG	unstable hemodynamics	6hrs	750ml	15hrs	-	-								-	expired	-
81	Rajan	43yrs	M	28809	CAD - SVD					Y	LAD	48%			B	1	1	LIMA		2.5hrs	300ml	12hrs	3days	10days								50%	discharged	50%

ABSTRACT

"ON-PUMP CORONARY ARTERY BYPASS GRAFT SURGERY VERSUS OFF-PUMP CORONARY ARTERY BYPASS SURGERY IN PATIENTS WITH LEFT VENTRICULAR DYSFUNCTION – A COMPARATIVE STUDY"

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Background: Treatment of significant coronary artery disease complicated with left ventricular dysfunction is challenging. Off-pump coronary artery bypass surgery is feasible and applicable for patients with left ventricular dysfunction, as it avoids the pump induced complications.

Aim: This study will compare the outcome, advantages and disadvantages of On-pump versus Off pump coronary artery bypass surgery in patients with left ventricular dysfunction.

Materials and Methods: 81 patients with significant coronary artery disease and ischemic left ventricular dysfunction were categorized into On-pump (42 patients) and Off-pump (39 patients) and underwent coronary artery bypass graft surgery. In the On-pump group cardiopulmonary bypass with aorta, right atrial cannulation, moderate hypothermia and cold cardioplegic arrest was employed, and in the Off-pump group, grafting was done with cardiac stabilizers. Patients were monitored in the immediate post operative and followed up for a period of one month and ejection fraction documented.

Results: The mortality, morbidity, complications, post operative bleeding, post operative ventilation, intensive care unit stay and hospital stay were less in the Off-pump group. There was significant improvement in the left ventricular function during the post operative follow up.

Conclusion: In conclusion, Off-pump coronary artery bypass surgery is a safer alternative to On- pump coronary artery bypass surgery in patients with ischemic left ventricular dysfunction.

Key words: OPCAB, Coronary artery bypass surgery, Ischemic left ventricular dysfunction, On-pump versus Off-pump bypass surgery.